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The ancient world, or, Picturesque sketches of creation

David Thomas Ansted

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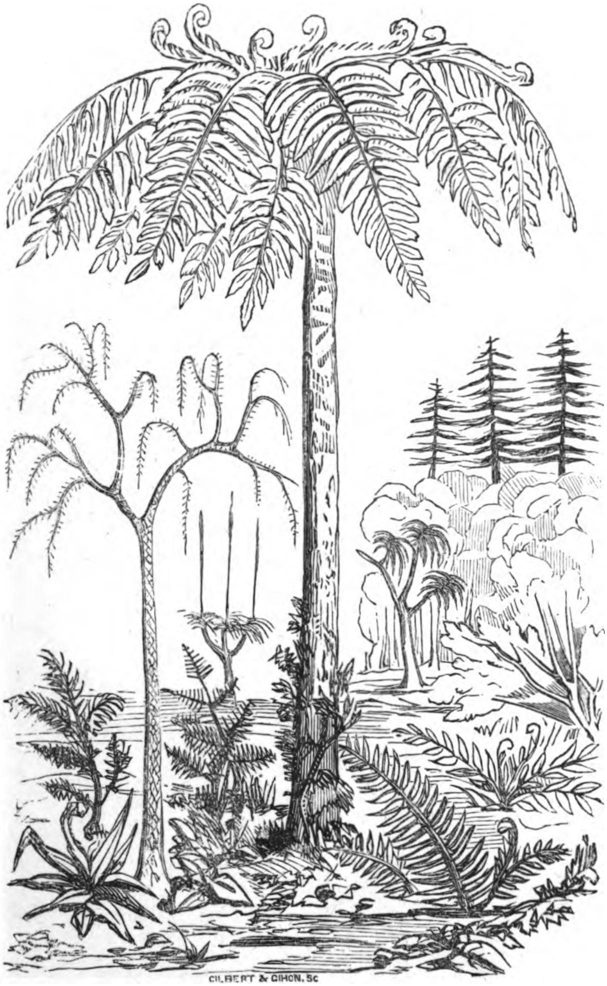

GILBERT & GIHON, Sc

THE VEGETATION OF ENGLAND DURING THE COAL PERIOD.—Page xii.

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OR,

PICTURESQUE SKETCHES OF CREATION.

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BY

D. T. ANSTED, M.A., F.R.S., F.G.S.;

PROFESSOR OF GEOLOGY IN KING'S COLLEGE, LONDON,

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PREFACE.

The object of this Work is to communicate, in a simple form, to the general reader, the chief results of Geological Investigation. No detailed account of particular districts,—no minute statements with regard to peculiarities of structure exhibited in various formations, or in their fossil contents,—must, therefore, be expected; and, on the other hand, the reader will be spared, as far as possible, the mere technicalities of the Science, while being informed of the views deduced from the study of them.

The Author hopes, that if, in thus endeavouring to communicate definite ideas concerning the Ancient History of the Earth and its Inhabitants, he shall be found not to express with perfect accuracy the whole amount of what is known in every department of Geological Science, his attempt may yet be received favourably, as a fair sketch of such history, at least in its broad Outlines.

More than this he does not attempt; nor would it be easy so carefully to digest all that is known, and so to harmonize conflicting views, as to satisfy every one on a subject which is still obscure in many important points.

CONTENTS.

CHAPTER I.

PAGE
EXPLANATORY AND INTRODUCTORY - - - - - 17

THE FIRST, OR ANCIENT EPOCH.

CHAPTER II.

THE PERIOD ANTECEDENT TO THE INTRODUCTION OF LIFE—THE DEPOSIT OF NON-FOSSILIFEROUS ROCKS - - - 30

CHAPTER III.

THE PERIOD OF THE EXISTENCE OF INVERTEBRATED ANIMALS AS THE MOST HIGHLY ORGANIZED INHABITANTS OF THE SEA—THE SILURIAN ROCKS - - - - - 37

CHAPTER IV.

THE INTRODUCTION OF FISHES, THE CHARACTERISTIC ANIMALS OF THE SECOND FOSSILIFEROUS PERIOD—THE DEVONIAN OR OLD RED SANDSTONE SYSTEM OF FORMATIONS - - 63

CHAPTER V.

THE APPEARANCE OF LAND AND THE INTRODUCTION OF LAND VEGETABLES—THE CARBONIFEROUS SYSTEM - - - 83

CHAPTER VI.

PAGE
THE CLOSE OF THE FIRST EPOCH OF CREATION—THE MAGNESIAN LIMESTONE, OR PERMIAN SYSTEM OF DEPOSITS - - 110

THE SECOND, OR MIDDLE EPOCH.

CHAPTER VII.

THE COMMENCEMENT OF THE SECOND EPOCH:—THE FORMATION OF THE NEW RED SANDSTONE, OR TRIASSIC SERIES - - 121

CHAPTER VIII.

THE MARINE REPTILES, AND OTHER ANIMALS CHARACTERISTIC OF THE LIAS - - - - - - 139

CHAPTER IX.

THE GIGANTIC LAND REPTILES, THE FLYING REPTILES, AND OTHER ANIMALS CHARACTERISTIC OF THE OOLITIC AND WEALDEN FORMATIONS - - - - - - 181

CHAPTER X.

THE INHABITANTS OF THE EARTH DURING THE CRETACEOUS PERIOD - - - - - - - 220

CHAPTER XI.

GENERAL CONSIDERATIONS CONCERNING THE SECONDARY EPOCH AND THE CIRCUMSTANCES OF ITS TERMINATION - - 245

THE THIRD, OR MODERN EPOCH.

CHAPTER XII.

PAGE
THE INTRODUCTION OF LAND ANIMALS AND THE COMMENCEMENT OF THE TERTIARY PERIOD IN WESTERN EUROPE - - 255

CHAPTER XIII.

THE CONDITION OF EUROPE AFTER THE OLDER TERTIARY BEDS HAD BEEN DEPOSITED, BUT PREVIOUS TO THE HISTORIC PERIOD 279

CHAPTER XIV.

THE CONDITION OF INDIA, AUSTRALIA, AND NEW ZEALAND DURING THE TERTIARY PERIOD - - - - 312

CHAPTER XV.

THE CONDITION OF SOUTH AMERICA DURING THE TERTIARY PERIOD - - - - - - - 330

CHAPTER XVI.

GENERAL CONSIDERATIONS CONCERNING THE RESULTS OF GEOLOGICAL INVESTIGATIONS - - - - - 357

DESCRIPTION OF THE FRONTISPIECE.

The Frontispiece is intended to give an idea of what may probably have been the aspect of Vegetation in England during the Coal period. The trees introduced are chiefly those living forms which seem most analogous to extinct species. In the centre is a tree fern, which was certainly a common and characteristic plant. On the left is represented an ideal restoration of a *Lepidodendron* (see p. 94;) on the right in the distance are the tops of Araucarias, coniferous trees nearly allied to which have been found in the coal-measures. The remaining trees and plants are inhabitants of Norfolk Island or Eastern Australia, but seem to have had representatives in ancient times.

PICTURESQUE SKETCHES

OF

CREATION.

CHAPTER I.

EXPLANATORY AND INTRODUCTORY.

LONG,—very long ago,—many ages before the creation of Man, this world on which we dwell existed as the habitation of living beings, different from those now tenanting its surface, or inhabiting the ocean which covers so large a part of it; but yet sufficiently resembling them to admit of that degree of comparison by which the general form, the proportions, the peculiarities of structure, and even in some cases the habits of these ancient dwellers upon earth may be determined.

The history of the succession of these beings, in that part of the world now occupied by the British islands, happens to be traceable with remarkable facility and certainty, presenting few breaks in the succession, except those common to most parts of the land hitherto examined. It is a history of antiquity which ought not to be neglected; it possesses a deep interest, although man does not figure among the *dramatis personæ;* and the history is clearly made out by a chain of evidence, different indeed in kind from that ordinarily resorted to for the establishment of historical views, but not for that reason less satisfactory or convincing. This history, too, is exceedingly important in its bearing on the wants and occupations of men; and upon the particular order and nature of the events it records have depended no inconsiderable proportion of the many physical advantages possessed by England over all the rest of the world.

The alternation of rich plains and hilly surface which characterizes our country, and which are so well adapted for cultivation—her valuable mineral resources of coal, and of iron and other metals—her insular position—her temperate climate—her capability of supplying almost all the wants of man;—all these must be ranked among the advantages derived by England from happy peculiarities in the arrangement and ordering of the materials which make up her superficial crust of mineral matter; and all are conditions the causes of which may be investigated. And if it is thought discreditable to an educated person to be unacquainted with the history of the people of his own country, it ought surely to be considered of importance that he should possess some degree of knowledge also concerning this much wider range of history, involving as it does an account of the revolutions and changes on which so many important matters depend; but yet how many people do we meet, otherwise well educated, who look with indifference, or even contempt, on this branch of knowledge!

In spite of the deep interest of the subject and its great importance, comparatively few are familiar even with the general nature of the successive events which have modified the whole surface of the globe; and I shall be glad if, in the following pages, I can give my readers a distinct appreciation of what is actually known with certainty concerning this new kind of history. In doing so I shall, I am sure, be doing good service, not only to science, but also to general literature; exhibiting a link little thought of, and an analogy almost neglected; and causing Natural History to appear, as it really is, an account of a succession of events, and not merely the description of the habits and structure of certain groups of animals and vegetables.

In thus undertaking to give an account of Nature and of her operations, from the earliest records not only of man but of Creation, I shall be somewhat in the condition of an author proposing to communicate the history of an ancient people who have left monuments of their existence in their ruined temples and mausoleums, but whose language is very imperfectly understood, and whose written documents are obscure and vague.

Now an historian in such a case would, doubtless, think it necessary first of all to make his readers aware of the kind of evidence he would have to adduce in attestation of his statements and descriptions; and it is manifest that, if there is an absence of the ordinary documentary evidence, it would be still more requisite that the credibility of his narrative should be supported by a constant and direct reference to facts, either evident in themselves or admitting of distinct proof.

There are not wanting instances, indeed, in which conclusions perfectly satisfactory have been arrived at, and histories prepared, without the existence of any written documents whatever. The domestic manners of the Egyptians have been clearly made out by an examination of that picture-writing which has been called *hieroglyphic;* and in the same way the careful observation and comparison of the figures painted on vases or sarcophagi has thrown light upon a similar subject of research, with regard not only to the ancient Greeks, but even the Etruscans, of whom at best we know very little, and absolutely nothing by any direct historical documents. The knowledge thus acquired indirectly is however valuable, because it may generally be thoroughly depended on; and if the facts so determined appear at first sight few and unimportant, they are found from time to time to possess an increasing value, and they are the more credible as being for the most part too unimportant in themselves to have been worth while to falsify.

Now, in a way not much unlike that which must be pursued in investigating this kind of history, it is possible to make out an account of the successive events that have taken place in various parts of the world, not only before the earth was inhabited by civilized men, but even when man had not yet been created.

Since, however, before attempting to give a history of a people, it must be perfectly certain that the people to be spoken of did once exist, so the reader has a right to require that, before commencing, as I propose to do, an account of the pre-adamite world, it should be clearly shown that there exist for this account the true materials of history, and that there is, in fact, that degree of order and system in the arrangement of the different parts of the earth's crust, without which there could be no connected or reasonable account of events.

The proof of such a condition is, however, at hand, and requires only that the very commonest appearances of nature should be studied. No one can visit a chalk or sand pit, or look for one moment at a stone quarry,—no one can consider the appearances so commonly presented by a sea-cliff, a cutting for a road, or a sinking for a well, without being perfectly convinced that the limestones, sandstones, and clays, of which a great part of the earth's crust is made up, were not thrown confusedly together, but are arranged in some degree of order, lying upon one another in regular beds or strata. A very little inquiry into the way in which these strata rest upon one another, is amply sufficient to prove that order does exist in the arrangement of the greater proportion of the materials of the earth's crust; and the more strictly this inquiry is carried out, the more convinced will the observer become of the great fact, that there is a history to be learnt—a succession of events to be described.

But it may be said, and with great reason, that the mere fact of order in the arrangement of these superficial materials proves nothing more than that they were deposited in succession, and they might either have been so placed at the first creation of the world, or, since the whole bears marks of aqueous action and of disturbance, that the successive beds may have arranged themselves as we find them during some great deluge. But the possibility of this is contradicted by appearances presented to the observer of nature at every turn, and by the result of every investigation, however superficial, when the actual structure of the earth is laid open, whether in the quarry or the sea-cliff.

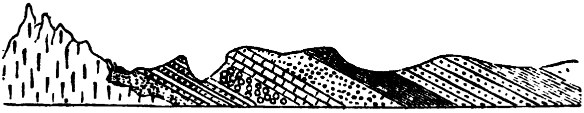
There are, indeed, so many distinct *facts* that prove both the nature of the deposits and the circumstances of deposition to have been very different from either a creation of the surface as it now exists, or the formation of such a surface by a deluge, that it is more easy to be confused with their number and variety, than to resist the conclusion when the reason is fairly appealed to. Among these facts we may perhaps select these three with advantage, as the most prominent, viz. (1.) That a vast number of strata may be discovered to rest on one another, and that they are of very great thickness and extent, and exhibit great variety both in the nature and condition of the materials of which each is made up; (2.) That the beds are found, in many cases, not lying regularly upon one another, but showing by their direction and inclination that one series has had time to harden, and be disturbed in position, before another was placed upon it; and (3.) That almost throughout the whole great and varied series of strata there are found the remains of a number of animals of different kinds, chiefly but not entirely of marine origin; each group of which presents in itself a history, and denotes a peculiar condition, both of the depth of the water, and the structure of the sea-bottom especially adapted for it. The proper consideration of the three facts, or rather classes of facts, thus alluded to, cannot fail to satisfy any one that the strata of the earth's crust were formed gradually and slowly, under various circumstances, and at different times. I do not mean, however, now to illustrate these facts at any length, because, in truth, they would involve the whole subject of Descriptive Geology, and would require the introduction of details, and the use of technical language, which it is my especial object to avoid. The reader must either take for granted that there are such facts, or he may satisfy himself concerning them by a very slight amount of observation and investigation.

Although, however, the following pages may not communicate any such argumentative proofs of the truth of Geological conclusions as would be required to convince those who are determined to doubt, yet actual observations will be presented to the notice of the reader in order, and the conclusions which alone seem rational will be narrated as history. My object in alluding to the series of investigations on which the science of Geology is founded, is rather to show how far there are supposed to exist materials for description and history, than to enter into any discussion or argument concerning these materials. It is enough that I have alluded to the nature of the facts, and the kind of observations required.

Taking it for granted, then, that there is something in the structure of the earth which requires and admits of investigation, let us next see how far this investigation can be carried with reason, and how far the structure of the globe is laid open for examination. The reader must indeed be contented to take upon trust the statements that will be made in this introductory chapter concerning Descriptive Geology, but he may be assured that they are too well established, and founded on too many observations, to be shaken, or even questioned.

In the first place, then, there is the evidence of what are called "Geological sections;" offering sufficient proof that the different strata of which the earth's crust is composed are of certain limited extent and thickness, and that they overlie one another in regular order. This kind of evidence reaches indeed farther, and proves very sufficiently that there is some characteristic mark of each group of strata by which it may be known and recognised; so that the kind of sandstone, limestone, or clay beds that may exist in one part of the series, and the order in which they succeed each other, is not so closely imitated in another part, but that a distinction may generally be drawn without much difficulty. Geological sections, and the maps which should accompany them, prove also in addition to this, that over large tracts of country, and even over whole continents, the same invariable order of arrangement of the strata may be traced; so that the Geologist is thus enabled to advance with some confidence, and frame those generalizations without which Geology could hardly exist as a science.

Fig. 1



SECTION ILLUSTRATING THE SUCCESSION OF DEPOSITS.

Besides this evidence, derived from the examination of the mere mineral materials of which strata are composed, there is however another, and a far more important means of acquiring a knowledge of the earth's history, derived from the study of the animal and vegetable remains that are found in almost every one of the whole series of strata which make up its crust. It is these organic remains—called sometimes *fossils*,* as being, of all things that are dug out of the earth, those of greatest interest to man in his efforts to penetrate into the past,—that afford most clearly and distinctly the information required concerning the history we need; and it is from them, and from studying the language they speak, that sound conclusions are arrived at in matters of the most interesting detail, as well as in the broadest generalities obtained in our history.

Fossils have sometimes been called the Medals of Creation, and to a certain extent the simile is a just one; for as medals serve to mark either an actual occurrence, or at least the view taken of a supposed occurrence by contemporary authorities, so fossils bear the impress of their date; they mark the condition of the earth at the time and place of their deposit, and in so far therefore at least they are materials for history.

But fossils are much more than mere indications of the history of the time to which they refer. They themselves express the very language of nature; they bear actual, direct, and unquestionable testimony to the course of nature; and when properly considered, and investigated with a view to those analogies which the study of existing nature teaches, they exhibit distinct proof of a long series of successive creations, characterizing different epochs in the earth's progress. They are also found to be, in a very distinct and important sense, characteristic of formations; by which it is meant that certain groups of species are chiefly met with in rocks of one age, the various species of each group being more rarely found in those of the preceding and succeeding periods, but never met with again in abundance. And this is not the less true because a few of them, escaping it would seem as if by some unusual powers of endurance, and stragglers from the general herd, have continued to exist for a long time, and through many subsequent periods.

---

* From the Latin *fossilis*,—that which may be dug out of the earth. The word was originally used in English as synomymous with mineral, but has gradually become limited to its present meaning.

From these two positions, both of which have been satisfactorily proved in the progress of Geology,—namely, that fossils are characteristic of formations, and that in all the different parts of animal and vegetable structure there is reference to every peculiarity of habit in the complete organized being; it follows that the study of fossils becomes an important and necessary branch of Geological research.

There are, however, two ways, by means of each of which satisfactory conclusions have been arrived at from the study of organic remains; and as, of these two, one chiefly bears upon Geology, while the other has reference quite as much to Natural History, generally, so both unite in laying the foundation, and building the superstructure, of that general history of the world which it is the true object of Geology to describe.

It is not difficult to explain the value of fossils in each of these two respects. To the Geologist they are of value, not only in the identification of strata in different parts of the same district when the mineral character of the beds is doubtful or variable, but also in determining those groups of strata which shall be either classed together as having something in common, or separated as entirely distinct. Viewed in this light, they become the groundwork of classification; and every successive observation proves that, when properly and carefully made use of, they are entirely to be depended on, as being not only the best, but the only safe means of separating some strata, and uniting others into groups. Such is their Geological value: and their bearing upon Natural History is no less real or important. They afford numerous links in the great chain of organized beings; they explain difficulties otherwise inexplicable; they suggest reasons and causes for the most extraordinary variations from the ordinary course of nature; and they teach us the important truth, that, throughout all time, there has been a perfectly uniform plan pursued in the construction of the world, and its adaptation for successive races of beings; but that this plan has admitted of innumerable modifications in the manner of carrying it out, all evidently adapted to changing circumstances.

In one word, it is by the proper interpretation of fossils that a science has arisen, unlike any other in its investigations; nobler than any, except Astronomy, in the object at which it aims; and more interesting than any, inasmuch as it combines every branch of Natural History, commonly so called, with those inquiries into a former condition of existence which are best calculated to attract the fancy and excite the imagination. Removed, however, from the condition which it long occupied, as an amusement for speculative men who were contented to imagine for themselves theories of the earth, and propound them for the astonishment, the admiration, or the contempt of the world, Geology has now become the receptacle of innumerable observations, carefully made and accurately recorded; and from this treasure-house of facts there must soon be derived a theory that will command attention, and a knowledge of laws not less universal than the law of gravitation, or the theory of the solar system. Meantime I propose in the following pages to arrange some of these facts in order, and so present them to notice, that, while the main results which they prove are plainly set before the reader, he need not be deterred from considering them by any too minute reference to the details of, the facts themselves, or the circumstances under which they have been discovered or observed.

But I must not proceed to the immediate subject without stating, in a few very words, the nature of the arrangement that I shall follow in my descriptions. In many cases the phenomena themselves, by a due consideration of which groups of strata are distinguished, will be stated and explained; but it will not always be convenient to do this, and in such cases I would have the reader recollect that I have not ventured to draw a line of demarcation unless nature has distinctly indicated it. These lines, however, are not all equally evident. In the whole series of strata exhibited in the British isles, there are, for instance, only two groups so natural, so unquestionable, and so real, that they render the task of classification easy and satisfactory. One of these groups is again subdivided, and this separation also is marked by a great change in organic remains, so that we have three sets of beds, which we may call respectively the Ancient, the Middle, and the Modern, and each of these we may conveniently look upon as denoting a lapse of time which we may call an "*Epoch.*"

The remaining subdivisions are often very strongly, though not so completely indicated; and to these I shall apply the name "*Period,*" as also sufficiently convenient. It will be found that the different epochs and periods described are in most cases distinguished by a commencement and a termination, often not the less interesting that each exhibits an occasional passage, both by mineral structure and fossil remains, into the beds of the next succeeding one.

In describing the groups of fossils, however, it will be necessary, in order to avoid repetition, that we should as far as possible confine our attention in each case to some group of animals or vegetables whose remains are most characteristic of the particular period which they are assumed to illustrate; and for the sake of convenience we shall often perhaps seem to neglect, or pass by with very slight mention, those which are nevertheless widely distributed in the rocks of the period under consideration. This might lead to some confusion, and even to wrong conclusions, if it were not understood beforehand that such apparent neglect is not without a reason.

In order to remedy this evil in some measure, I have here appended a tabular view of the various periods, in the order in which they will be treated, and with particular reference to the forms of organic life most strikingly exhibited in each. By glancing the eye over this table, the reader, however little acquainted with the details of Geology, will at least be enabled to recognise the plan, and will thus enter on the descriptions with some general notion of their bearing on the whole range of creation.

Tabular View of the Successive Geological Periods.

III. The Modern Epoch.	10. The Period of the caverns and gravel; with Carnivora, the Megaceros and other gigantic ruminating animals, and the elephants of Europe; and of various gigantic animals in Asia, America, Australia and New Zealand. (*Newer Tertiary.*)
	9. The Period of various large animals of the Middle Rhine valley, succeeded by that of the mastodon and elephants in North America, England, Northern Europe and India. (*Middle Tertiary.*)
	8. The Period of the pachyderms of the Paris basin, and of the sub-tropical (?) fruits and animals of the London and Hampshire Basins. (*Older Tertiary.*)

II. The Middle Epoch.	7. The Periods of the *Chalk* and *Greensand*; during the deposit of which there was probably a deep sea, covering a large proportion of the existing land.
	6. The Periods of the gigantic land reptiles, the flying reptiles, the gigantic crocodilians, and the first introduction of mammalian animals. (*Wealden* and *Oolite*.)
	5. The Periods of the frog-like, bird-like, and marine reptiles. (*Lias* and *Trias*.)
I. The Ancient Epoch.	4. The Periods marked by the presence of vegetables and the first introduction of reptilian animals. (*Permian* and *Carboniferous*.)
	3. The Period of fishes. (*Devonian*.)
	2. The Period of invertebrated animals. (*Silurian*.)
	1. The Period antecedent to the introduction of life.

THE FIRST OR ANCIENT EPOCH.

CHAPTER II.

THE PERIOD ANTECEDENT TO THE INTRODUCTION OF LIFE. THE DEPOSIT OF NON-FOSSILIFEROUS ROCKS.

JUDGING from the general appearance of the solar system, and combining the result of astronomical observations on distant bodies in the universe with the appearance presented by various rocks on the earth's surface, it seems not unlikely that, at a very early period of its history, our globe existed as an intensely heated body in a fluid state, (the fluidity being the result of igneous fusion,) and that it gradually cooled at the surface, perhaps by exposure in space, contracting in dimensions as it cooled and hardened. In this manner, it may be, a succession of thin solid crusts were formed, each in succession shrinking and cracking, until at length when a certain balance was arrived at between the thickness of the crust, the rate of cooling, and the amount of internal heat, there would be left a rough uneven surface, having many elevations and depressions, its temperature being sufficiently reduced to allow of the existence of some such atmosphere as now surrounds it, and also permit the permanent presence of water in a fluid state reposing in the hollows, and forming seas, lakes, and oceans. During the whole of this time, and until the existence of water in the liquid state, and the establishment of a sea, and perhaps long afterwards, it is likely that there were no living beings on the earth; because so far as we know, neither animal nor vegetable can exist, and perform its functions, at the temperature of water actually boiling,*—although at a temperature not much short of that, some small animalcules, and even some animals of higher organization, would seem capable of enjoying life. Thus, therefore, according to this view,—and the reader will understand that it is merely offered as the most probable explanation of certain appearances observed,—the first period of the existence of the earth as a planet was marked by a chaotic state of igneous fusion, and characterised by frequent disturbances of the surface consequent upon cooling from such a state. Let us consider for a moment what kind of rocks are exhibited to us when we examine these earliest records of our globe, and let us see also how far we are able to examine them.

In the first place we often find, as the basis of all other rocks in mountain-chains, and throughout some extensive tracts of country a well known-rock called *granite;* a rock whose structure is crystalline, and which bears strong marks of having cooled slowly from a state of intense heat. This rock is found in all parts of the world, and sometimes in widely extended masses. It generally exhibits its own characteristic features with sufficient distinctness to leave no doubt as to its nature; and it may be found in our own island, as, for instance, in Cornwall, Wales, and Scotland; and in other parts of Europe, as in the Scandinavian mountains, the Hartz, the range of mountains separating Northern Germany from Bavaria and Bohemia, in the Alps both of

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* This refers, of course, to the boiling temperature of water at the earth's surface with the present atmosphere. There is no proof of any change in the gaseous condition or pressure of the air, neither do we know what would be the condition of the surface with a *steam* atmosphere.

Switzerland and the Tyrol, in the Pyrenees, and in the Carpathians. In Asia it forms the centre of the Caucasus; it occupies a large part of the Himalayan, Uralian, and Altai mountains; and is found also in Siberia. In Africa it appears in upper Egypt, in the Atlas mountains, and at the Cape of Good Hope; and it may be traced along the Western part of the whole of the two Americas, and appears again in the Southern Islands and in Australia.

A rock so universally extended might, almost for that reason, be looked upon as the foundation and the main solid frame-work of our globe. It must not be lost sight of, however, that in many cases the granite has been, if not formed, at least placed in its present position, in a pasty or fluid state,* long subsequent to the early period of which we are now speaking; and thus, though we may safely consider the granite as frequently the oldest rock, we should always remember that a material so widely extended and so important, may be elaborated and expelled from the deep recesses of Nature's store-house at any time, and even at the present day.

I shall not detain the reader any longer with an account of the rocks which have been called "*Primitive,*" but shall quit this subject with a remark which, from the manner in which I have spoken of granite, may perhaps be necessary. It is this: that there are many kinds of granite and granitic rock, some of them very different from ordinary granite in appearance, and that there are also many other so-called primitive rocks very different in structure; but these varieties do not prevent the account I have given from being sufficiently accurate for my purpose, and I trust the reader will not suppose, when he has read through this little volume, that he has learnt every thing in Geology.

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* In either case the result of intense heat acting under enormous pressure.

Next in order to the crystalline rocks, and almost as widely extended, there are two or three others, often themselves crystalline, but bearing evident marks of what is called "mechanical structure," or, in other words, of having been deposited from water. These may be described as gneiss, mica-schist, and clay-slate.* If we imagine common granite coarsely pounded, and thrown into a vessel of water, it will arrange itself at the bottom of the vessel in a condition very much like that of gneiss, which is indeed nothing else than stratified granite. If the water in which the pounded rock is thrown is moving along at a slow rate, and that part of the granite called *felspar* happens to be somewhat decomposed, as it often is, then the felspar (which is so truly *clay*, that it makes the best possible material for use of the potteries,) and the thin shining plates of mica will be carried farther by the water than the lumps of white quartz or flint sand, which with the other two ingredients made up the granite; and the two former will be deposited in layers, which, by passing a galvanic current through them, would in time become mica-schist. If the mica were absent, or if the clay were deposited without it, owing to any cause, then a similar galvanic current would turn the deposit into something like clay-slate. These three mechanically arranged rocks are found abundantly, surrounding and overlying the granite, as if they had been formed from its broken and rough edges, worn away by the waters of the first ocean, and afterwards deposited at the bottom of the sea. In these rocks we have arrived at a second period, still unmarked by life, although apparently better fitted for sustaining it; our earth being then not merely a chaotic mass of cracked and burnt rock, but having had superimposed upon that mass extensive and thick layers of various materials; these contain in their composition most of the elements, both gaseous and solid, by certain combinations of which living animals and vegetables were enabled to perform their functions, and render inanimate matter available for their different wants.

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* Under this name "clay-slate," I only mean here to include those slates, whether of distinctly crystalline structure or not, which present no marks of having contained fossils. That there are such, no Geologist will, I suppose, doubt; but when the name *clay-slate* is given, as it is sometimes, to fossiliferous beds, they ought to be referred at once to the period indicated by the kind of fossils discovered.

One of the most remarkable facts with regard to these ancient deposited rocks, is their extraordinary thickness in some localities. It is not difficult to understand, that at a time when the granite and granitic rocks were newly formed, and presented innumerable fractured edges in every direction, the pounding action of moving water, especially if that water was of a high temperature, might grind down the exposed rock with extreme rapidity, and produce extensive deposits, rapidly filling up hollows and depressions. But we can hardly suppose the existence of depressions so considerable as the thickness of the gneiss and clay-slate would require; and it is far more reasonable to assume that a contraction of the crust, the result of gradual cooling, produced a series of wave-like motions in the earth's crust, alternately elevating and depressing portions of the surface, and sometimes producing a succession of elevations or depressions on the same spot. However this may be, it is certain that these old sedimentary rocks have been not unfrequently altered so as to have become crystalline; and they are also very often cracked and broken, the cracks being sometimes filled up with rocks of a different kind, injected apparently in a melted state, and sometimes with other materials, also crystalline, and often containing a greater or less proportion of metallic ore.

Thus do these lowest sedimentary strata, whose vast antiquity is in many cases unquestionable, but which sometimes, like the granite itself, have been elaborated at later periods, occupy a definite place among the rocks of which the earth's crust is made up. They mark, it would appear, a strange and dark passage from that state which we have considered chaotic, to a condition of more regular and quiet deposit; they are, however, with reference to fossiliferous rocks, *azoic*, or lifeless; and they are also as a class almost as widely spread, and as distinctly universal, as the granitic rocks themselves. At the end, therefore, of this our first period, we may suppose that there existed a globe, whose surface exhibited alternations of land and water; the land having in some places as distinctly stratified an appearance as it has at present, and the thick masses of strata resting on huge bosses and peaks of granite and other igneous rock:—but all was then bare and desolate; not a moss nor a lichen covered the naked skeleton of the globe; not a sea-weed floated in the broad ocean; not a trace existed even of the least highly organized animal or vegetable; every thing was still, and with the stillness of absolute death. The earth was indeed prepared, and the fiat of creation had gone forth; but there was as yet no inhabitant, and no being endowed with life had been introduced to perform its part in the great mystery of Creation.

It must, however, be distinctly understood that this view is strictly hypothetical, and is, after all, only one means of explaining certain phenomena. So far as it is an illustration of facts that have been observed, it has its value, and may be received provisionally; but, so far as it is merely a theory of the earth, it is worth neither more nor less than other different theories, many of which were proposed by cosmogonists of ancient date, and some have been put forth in our own time by persons who have as little grounds for theorizing. I have chosen in the present c ase to present it as a sketch, embodying many facts and results of observation, although the cause of the absence of fossils in metamorphic rocks, and of the other appearances that have been observed, may undoubtedly have been very different.

It is not, indeed, till we advance one step further, and consider the condition of the earth, by comparing what we know of its inhabitants with our speculations concerning the position of land then existing above the water, that we can arrive at conclusions at all satisfactory.

The additional facts made known by studying the remains of animals and vegetables found in the various rocks, give a new aspect even to the form of the speculation; and we shall soon perceive how far this view of the earliest condition of the globe is probable, when we study the first known results of creative power in reference to organic beings.

CHAPTER III.

THE PERIOD OF THE EXISTENCE OF INVERTEBRATED ANIMALS AS THE MOST HIGHLY ORGANIZED INHABITANTS OF THE SEA.—THE SILURIAN ROCKS.

Wrapping round the igneous rocks of Cumberland and the lake district, ranging over a considerable part of the north-east of Ireland, occupying a large portion of South Wales, and present almost every where in North Wales, there are found a great number of sedimentary rocks of various kinds, covering the gneiss, mica-schist, or clay-slate, and covered up in South Wales by a series of coarse red conglomerates or beds of pudding-stone. These sedimentary rocks are expanded sometimes to a thickness of many thousand feet, and they form a remarkable and natural group, which may be conveniently subdivided into two parts, the lower being by far the most considerable in vertical thickness, but the upper containing a greater number and variety of the fossil remains of animals.

In the British Islands, and very generally in other countries, this lower group of rocks consists of a grayish-coloured sandy stone, often slaty or flaggy, and containing much clayey matter, sometimes including poor bands of limestone, and not unfrequently exhibiting, in the partings between two beds, a number of imperfect remains of shells and other organic substances. From its frequently assuming the appearance of clay slate, and being indistinguishable from that rock except by the presence of fossils, it may be supposed that the materials of which it is for the most part formed were obtained from older, and probably from igneous, rocks pounded still more finely at the bottom of water, and forming fresh combinations, often marked by the presence of sand obtained from the quartz of the granite, and also occasionally distinguished by the presence of mica.

In those parts of England and Wales in which these rocks have been discovered, they have been found to exhibit indications of very extensive disturbance, and, in some cases, seem to have been deposited alternately with great masses of igneous rock poured out like lava from a volcano, but erupted through the bed of the ocean, and soon covered up with new deposits. Besides disturbances of this kind, these same rocks have in North Wales been subjected to so much squeezing, under a great pressure from above, that they are twisted into folds repeated several times, just as a number of pieces of cloth might be thrown into wave-like folds if squeezed by lateral pressure, with a heavy weight resting upon the upper surface. No description, however, can at all do justice to the singular complication thus introduced into the huge masses of hard and tough rock. In one place the strata are snapped asunder and displaced, in another they are bent nearly double like sheets of paper. Here the slaty beds are contorted into the most strange and violent curves; there the opposite cliffs of a narrow glen exhibit them torn asunder like fragments of soft wood or semi-tenacious paste.

Nor should it be supposed that such appearances are confined to the slaty and tough beds of this particular period. They are as common in the older schists, and in the gneiss, as in these strata, and they appear again in the similar rocks of the next newer period; but there is this difference observable in the case of England, namely, that the disturbances seem either to have diminished in intensity, or to have produced a smaller effect at each later time, while they are nowhere more remarkable than in the case of the lower silurian strata of North Wales and Cumberland.*

In these ancient beds, so greatly altered by mechanical violence from their original condition, often deposited amidst much disturbance, and presenting so many analogies with the earlier and non-fossiliferous stratified rocks, we find for the first time distinct marks of the existence of beings endowed with life.

We naturally turn with considerable interest to inquire concerning the nature of the inhabitants of our globe, as exhibited by their remains in these rocks; and in doing so, we find, that, although the conditions were, in some respects, very different, and the animals often unlike existing species, there is yet sufficient analogy to enable us to determine with considerable certainty the nature of the groups of species living in the sea at that early period.

The first thing that strikes the geological naturalist, in looking over the numerous fossils obtained from the great series of the lower silurian rocks, is the apparent want of fishes, and, indeed, of all vertebrated animals. We find every where abundant proof that these great thicknesses of mud and sand, with occasional bands of imperfect limestone, were formed at the bottom of water, and at various depths; some, in all probability, in shallow water near land, and others in the deepest recesses of the ocean; but nowhere throughout their wide spread in all parts of the world have they yet yielded the smallest fragment that could be referred to a fish. It is, therefore, pretty clear, either that fishes had not then been created, or that the conditions for their development were so unfavourable that they were extremely rare, and formed no important group among the inhabitants of the sea, in places where other organic remains, often found in newer formations accompanying fishes, are very abundant. The animals we do find consist of certain sea-weeds, called *Graptolites*,[*] the habitation, probably, of compound creatures,[†] which seem scarcely to deserve the name of animals; of other polyps of somewhat higher organization, building those singular and lasting monuments, the coral-reefs; of animals removed yet another step in advance, and called *Crinoids*;[‡] and of a singular and extensive group of crustacean animals, known by the name of *Trilobites*.[§] They also include a considerable group of bivalve shells belonging to animals of low organization, and allied to the Terebratula; of a few other shells, both bivalve and univalve; and, last of all, of a number of the many-chambered shells of a carnivorous animal[‖] like the cuttle-fish,—a creature of high and complicated organization among the Invertebrata, and which seems to have been introduced among the very earliest of the species intended to people the primæval seas. All these animals must have been to a certain extent contemporaneous; and it is worth while to remark, concerning them, that they exhibit some instances of very imperfect, and some of the most perfect, development of the great kingdom of nature to which they belong. In the older beds, at least until the termination of the first great epoch, the silurian, there seem, indeed, only to have been introduced successive modifications and additional species of the invertebrated type; and not till its close did the fishes appear, as if preparing the way for the next period, marked by the prevalence of these more highly organized beings.

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* The evidence of great disturbance observable in these beds in the British Islands does not extend to Russia and Scandinavia, where they also occur. Here, and in other parts of the world, they have been less disturbed, but their general character is the same.

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[*] *Graptolites*, γραπτος (*graptos*,) written upon; λιθος (*lithos*,) a stone—from their appearance.

[†] Allied to the recent family of *Sertularidæ*.

[‡] *Crinoids*, κρινος (*crinos*,) a lily; ειδος (*eidos*,) resembling. Lily-shaped animals.

[§] *Trilobites*, three-lobed, so called from their shape.

[‖] *Orthroceratites*, and several allied forms.

As the animals of the newer differ so little from those of the older portion of the first period, at least in points which admit of general description, I shall not describe them separately; but, having already offered a few remarks on the mineral structure of the rocks, I shall proceed at once to explain in succession those groups which are most interesting and characteristic. In this way I hope to communicate something like a distinct notion of the results of geological investigation with regard to the first inhabitants of the earth, and not only show the general fact, that important changes must have since taken place in the condition of the sea-bottom, but also explain the nature of some of those changes.

According to the actual constitution of things, the soft substance of the bodies of animals consists chiefly of carbon in combination with gases (oxygen, hydrogen, and nitrogen;) and the more solid parts, whether forming a bony skeleton, or a yet harder external case, or internal framework of stone, are composed of salts of lime with little admixture of other material, especially in the invertebrated animals. The presence of carbon, lime, and these gases, therefore, in sufficient abundance under favourable circumstances of temperature and in a condition to combine with other elements, is all that is required to enable animals once created to carry on the functions of life.*

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* It is indeed true, that at present most of these inorganic materials are first prepared by vegetables into a fit pabulum for the animal; but it seems by no means certain that the lower animals cannot themselves perform the required change. Even if this is not the case, there is sufficient proof in

Of such substances, those existing in a gaseous state were, no doubt, sufficiently abundant during the earlier periods of the earth's development: carbon, of which so large a quantity is still given off in volcanic districts in the form of carbonic acid gas, must also have been abundant then; and a sufficient proportion of lime and silica is found in the composition of felspar—one of the most important and universal ingredients of granite—to supply the marine animals with materials for their stony houses. It has, indeed, been thought possible, though perhaps it is not very probable, that our atmosphere at its first formation contained a larger supply of carbonic acid gas than at present; but such an assumption is not at all necessary to account for the first secretion of carbonate of lime required to form the habitations and the skeletons of the original inhabitants of our globe.

Fig. 2

Sertularian Coralline.
(*Graptolite.*)

Among the most simply organized of the silurian species, and amongst those found in the beds of oldest date, are the fossils called *Graptolites*, which seem to have been the horny skeletons of animals not unlike those which are often met with on the coral and sea-weeds of our own coast. They were formed, like these, by a vast multitude of individual polyps attached to a tough central mass, the whole constituting a kind of compound animal, in which each individual works to increase the general mass, and is affected by that which affects this mass; but each, also, has a separate existence, being provided with a

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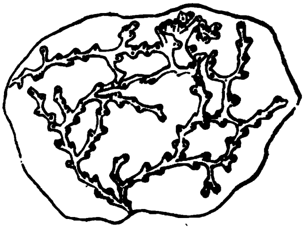
some of the most ancient fossiliferous rocks, that large masses of sea-weed existed as soon as any other organized substance.

stomach and arms, to obtain and digest food, and capable of being injured or destroyed without the functions of the complete body being at all interfered with.

Polyps, as animals of this low organization are called, appear to have been among the first of created beings, and are also those which have been changed least since the period of their original introduction up to the present time. Their extreme simplicity of structure would, probably, enable them to live through many changes, since they could adapt themselves to altered conditions of temperature and position, at times when almost every other animal was destroyed; and, accordingly, in the species of them found fossil, there is far less difference from existing nature than is the case with any other creatures. These little corallines, and the larger and more important group of true corals, as they commenced existence so early, seem also to have been comprised within a very limited number of natural families, and some particular species probably extend completely through the whole number of beds of the first great epoch.

Amongst the earlier forms are those of the genera *Aulopora* (3) and *Catenipora* (4, 5,) all belonging to the group of lowest organization among coralline bodies, and having the most solid stony or horny framework. They are radiated and star-like in their structure, have no true intestinal canal, and in many, though by no means all the species, the animal is capable of locomotion. The species figured 3 is common in rocks of the older palæozoic period, and is closely analogous, in many respects, to species yet inhabiting tropical

Fig. 3



SIMPLE FLOWER-LIKE CORALLINE.
(*Aulopora.*)

and southern seas. The chain coral (4, 5) offers another and a beautiful example of this peculiar structure, and being a fossil exceedingly common in some silurian localities, is well adapted to illustrate the habits of the group.

The little animals in these cases secreted and built up their stone house, they added compartment to compartment, erecting in succession one story after another, and they continued at this work month after month, year after year, century after century, until at length they were replaced by others like them, when the depth had changed in which they could most conveniently live, or when, owing to some cause, their labours were brought to a close, and they disappeared from amongst existing forms.

Fig. 4

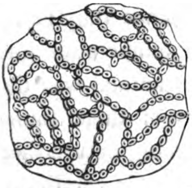
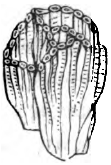


Fig. 5



CHAIN CORAL. (*Catenipora.*)

During every successive period from this their first appearance in the infancy of the world to the present day, animals of the polyp kind have been perpetually adding to the solid matter of our globe, by these singular buildings of stone. These little creatures are enabled to separate from the sea-water a proportion of carbonate of lime, and they do this although the quantity present is so minute as to be almost inappreciable by the most careful chemical analysis. The most common species are known to be unable to exist at a greater depth than twenty or thirty fathoms; but there are many instances in the southern seas of corals forming part of extensive reefs existing at a much greater depth, and they are also sometimes elevated high in the air. Great changes of level must, therefore, have occurred; and these are perhaps still going on; and by similar changes we must account for the presence of lofty masses of solid rock exhibiting the remains of the ancient coral polyp in the old rocks.

The prodigious extent of the combined and unintermitting labours of these little world-architects must be witnessed, in order to be adequately conceived or realized. They have built up four hundred miles of barrier reef on the shores of New Caledonia; and on the north-east coast of Australia their labours extend for one thousand miles in length; and these reefs may average, perhaps, a quarter of a mile in breadth, and one hundred and fifty feet in depth, and they have been built amidst the waves of the ocean, and in defiance of its fiercest storms. The Geologist, in contemplating these stupendous operations, learns to appreciate the circumstances by which were deposited in ancient times, and under other conditions than those which now characterize our climate, those mountain masses of limestone, for the most part entirely coralline, which abound in many parts of our native island. The most abundant remains of corals in these masses are similar in their general nature to living species, but indicate animals very distinct from those living polyps which are now actively engaged in forming similar deposits on the undulating and half-submerged crust of the earth washed by the Indian and Pacific oceans. The limestones, which form a part even of the oldest formations, offer distinct proof, by their organic remains, that they are due to the secretions of gelatinous polyps, the species of which perished before those that formed the newer strata were created; and, as these polyps of the older period have been superseded by those of the present day, so these, in all probability, are destined to give way in their turn to new forms of essentially analogous animals, to which, in time to come, the same great office will be assigned,—to clothe with fertile limestone future rising continents.*

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* Owen's Lectures on the Invertebrata, p. 93.

The polyps thus collecting calcareous matter in large quantities, and building vast masses of solid limestone, secrete their stony skeletons on the outside of their soft bodies. If, however, we suppose the animals supported on a stem, and that, instead of depositing the earthy particles externally, they are placed in regular shape and order in the substance of the polyp itself, and fill up the stem, the cup-shaped body, and the arms or feelers that surround the mouth, there would result an animal of a very different kind, not capable of associating with others of its species to form a compact mass, but possessing a separate and distinct existence, and building a kind of stone plant, of which the roots, the trunk, the branches, and the smaller twigs are each made up of a number of separate and detached particles. A skeleton of this kind, however curious it may seem, was possessed by a vast number of distinct species of animals living in the early seas, and such forms were continued through the whole of the first and second epochs, gradually, however, diminishing in number, and at present scarcely presenting an adequate representative in two or three comparatively small and unimportant species of what are called *Crinoidal* animals.

The very name which is given to these animals is illustrative of their curious structure and the arrangement of their hard parts. They are called *Encrinites*, or Crinoidal animals, because many of them exhibit the appearance of a cup-shaped flower, opening on the top of a stalk; this flower-like shape being comparatively simple in many species, while in others there is a complication in the number of branches stretching out from the principal stalk, and in the multitude of arms and fingers projecting from the aperture of the mouth, which seems quite unrivalled in complexity in any other animal, whether recent or extinct.

A remarkable form of these crinoids existed during the silurian period, and served, as it were, to introduce these pretty and curious examples of organization.

The figure (7) exhibits the structure of the stony case in one species; and the annexed figure (6,) shows the step by which this ancient family, apparently the first introduced, passed on to the higher organization of the modern starfish. The animal was without arms, and was inclosed within stony plates, whose number was sometimes indefinite, but an orifice was left in the central part of the upper surface (*m*) for the mouth; an adjacent orifice (*a*) was provided, from which the undigested parts of the food could be ejected; and also a third, at no great distance (*o*,) for the expulsion of the eggs. The mouth was provided with a proboscis, moveable and covered with small plates; while the orifice *o* was covered with a little five or six-sided pyramid, made up of as many little valves. The whole stony case, which, in some instances (*Sphæronites*,) resembles a little green orange, was supported on a very slender stalk, which, however, is rarely preserved. In the more advanced form (6,) the mouth and proboscis are still present, but there were a number of arms projecting from the summit around the mouth; and the orifices do not exist, since the eggs were carried out at the openings for the arms. The fossils exhibiting this singular structure are by no means common; but they afford so beautiful a transition from lower to higher forms, and are so little known, that a notice of them cannot fail to be interesting. Fragments of encrinites, more resembling the

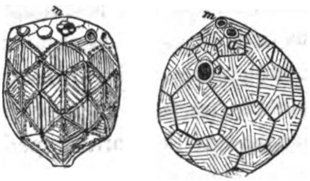
Fig. 6 *Fig.* 7

SILURIAN CRINOIDS. (*Cystidea.**)

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* 6, *Caryocrinus ornatus.* 7, *Caryocystites granatum.*

modern types, are common in some of the rocks of the older period, and are much like fossils of the same family found in the upper members of this group of rocks.

The encrinites, although so nearly like the coral polyps in some points of structure, and in the simplicity of their organization, belong, however, to a much higher group, and exhibit important resemblances to the star-fishes; and just as they are the least organized of the star-fishes, and as the coral polyps are the lowest of that group of Zoophytes which possess no trace of nervous filament, so among the Crustaceans of the earliest period (a great natural group, including the crabs, the lobsters, &c.) we find nearly a similar peculiarity; the species most commonly found in the older rocks exhibiting very simple structure, although developed to a great extent in point of number at one time, and only dying out towards the close of the first epoch. These animals are called *Trilobites*. (See figs. 8, 9, 10.)

Fig. 8 *Fig.* 9

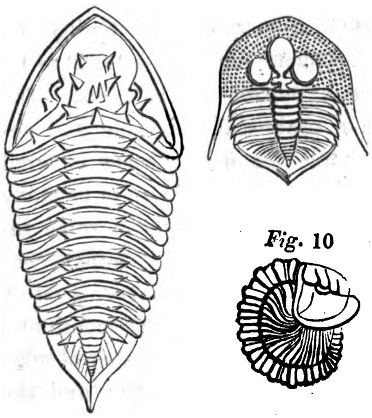

Fig. 10

TRILOBITES.*

The trilobites, of which there is a considerable number of distinct generic forms in the older rocks, were provided with a large semicircular or crescent-shaped shield, completely defending the head; their body was in like manner secured from the attack of an enemy by a number of plates

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* 8, *Homalonotus armatus.* 9, *Trinucleus Caractaci.* 10, *Calymene Blumenbachii.*

or segments moving readily upon one another, like the horny plates of a shrimp; and the tail was armed with a similar series. The animal seems not to have had antennæ, and to have possessed short and rudimentary legs; but on the head were placed a pair of large conical projections covered with eyes, by the help of which any approaching danger might be seen; and the power of rolling itself into a ball (see figure 10,) which it possessed in common with the wood-louse and the chiton, enabled this creature, no doubt, to escape the attack of many of its enemies. It is not very easy either to make out the habits of an animal of such singular organization and of which only the hard external coat is preserved, or speculate with regard to its food and its method of obtaining it. From the absence of antennæ, however, and the want of powerful extremities, as well as from the manner in which these fossils are found,* the different species probably lived for the most part in shallow water, not buried in mud, but floating near the surface with their under side uppermost, feeding on the minute and perhaps microscopic animalcules that usually abound in such localities. There are several natural groups, marked by differences somewhat considerable, but the number of species is not great.

The most remarkable point with regard to these trilobites is the presence of the large compound eyes with which they were provided. These eyes appear to be constructed on the same principle as those of the dragon-fly and other insects: they are ranged round about three-fourths of two conical projections rising one from each side of the head, and they are so placed that the animal, without moving from the spot in which it might be, could see in all directions around it. It appears, from this perfect and complicated contrivance, that, at the earliest period of the introduction of animals, the general conditions of light and the atmosphere could not have differed in any important degree from those which now obtain.

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* They seem to have been very gregarious, living by thousands in a single locality, and often heaped upon one another.

Together with the graptolites, the corals, the encrinites, and the trilobites, there seem to have existed as contemporaries, two, or perhaps three, very remarkable tribes belonging to the great natural group of *Mollusca*—a division of the animal kingdom readily distinguished from those which we have already had occasion to refer to, by the possession of a much more distinct nervous centre, and conducting the naturalist by slow and successive steps to that more complicated structure met with in the vertebrated animals, of which the fishes form the least highly organized group.

The Mollusca, as at present understood, are divided into six classes: some, as the *Barnacles* (CIRRHOPODA,[*]) fix themselves when young to the surface of various sub-marine bodies, and having no organs connected with the higher senses, and being unable to change their position, are content to cast out at intervals their ciliated (or hair-like) arms, which form a net of Nature's own contrivance, and entrap such passing prey as suits their appetite. Others, equally incapable of locomotion, but furnished with arms of different construction, catch their food by similar efforts: these are called BRACHIOPODA.[†] The TUNICATA,[‡] enclosed in tough leathery bags, are firmly rooted to the rocks, or, collected into singular compound masses, float about at the mercy of the waves. The CONCHIFERA[§] inhabit bivalve shells; the PTEROPODA[*] swim in myriads through the sea supported on two fleshy fins, and some of them enclosed in delicate fragile shells; while the GASTEROPODA,[†] defended in most cases by a shelly covering, creep upon a broad and fleshy ventral disc, and endowed with this locomotive apparatus, exhibit senses of proportionate perfection. Lastly, the CEPHALOPODA,[‡] the most active and highly organized of this large and important division of animated nature, are furnished with both eyes and ears, and armed with formidable means of destroying prey, so that they are thus enabled to become tyrants of the deep, and gradually conduct to the most exalted type of animal existence.[§]

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[*] Κιρρος (*cirrhos*,) a curled lock of hair; ποδα (*poda*,) feet.

[†] Βραχιων (*brachion*,) an arm; ποδα (*poda*,) feet.

[‡] *Tunicatus*, clad in a tunic or enclosing membrane.

[§] *Concha*, a shell; *fero*, to carry.

Of these classes of Mollusca, most of them seem to have been introduced at the very commencement of the existence of our globe: but two groups have since then greatly diminished in number and relative importance, although each is still represented in our own seas: these are the *Brachiopoda*, and the *Cephalopoda*. The Conchifera and Gasteropoda, or ordinary bivalve and univalve molluscs, seem to have been at first either totally absent or extremely rare; and, although they afterwards increased, they do not seem to have taken the place of the Brachiopoda till after the close of the second great epoch; while the Cirrhopoda and Tunicata may indeed have existed, but have left no remains of their existence in the ancient rocks.

The Brachiopoda were unquestionably the chief and almost the only representatives in the primæval seas of that large class of animals inhabiting bivalve shells, which were then scantily distributed, but now perform an important

[*] Πτερον (*pteron*,) a wing; *ποδα* (*poda*,) feet.

[†] Γαστηρ (*gaster*,) the belly; *ποδα* (*poda*,) feet.

[‡] Κεφαλη (*cephale*,) the head; *ποδα* (*poda*,) feet.

[§] Rymer Jones's Animal Kingdom, p. 352.

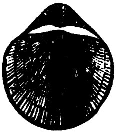
part in the great world of waters. They exhibit, however, an internal organization extremely simple compared with that of the other bivalves, together with a complexity in the structure of the shell, and in the contrivances for keeping the two valves partly asunder, which are quite peculiar to them. The shell, too, is generally laminated, or even fibrous in its texture: numerous long hairs seem to have passed, in some cases, from the plates, while in others they passed through the plates of which the shell is made up. Nothing can well be imagined more varied than the contrivances by which the ancient species of this group were enabled to obtain existence.

The two valves of brachiopodous shells are not connected by any hinge; but the lower valve was either directly fastened to a rock or some marine substance, or a bundle of fibres or hairs passed through one valve from the other, and were collected into a pedicle or foot-stalk, by which the animal could attach itself at will. Two arms, or tentaculæ, were wound in a spiral within the shell when at rest, but were capable of being expanded in search of food; and these being covered with cilia—those peculiar hair-like appendages frequently met with in animals of imperfect organization—powerful currents were produced in the surrounding water, which being directed towards the mouth as a focus, would hurry into that aperture whatever nutritive particles might chance to be in the vicinity.* The food of these creatures consisted probably of the minutely divided and decomposed particles of dead animals of various kinds floating about in the seas; and different species seem to have been enabled to live at various depths, varying from a few fathoms to the deepest abysses at which any appearance of life is met with.

* Rymer Jones's Animal Kingdom, p. 365.

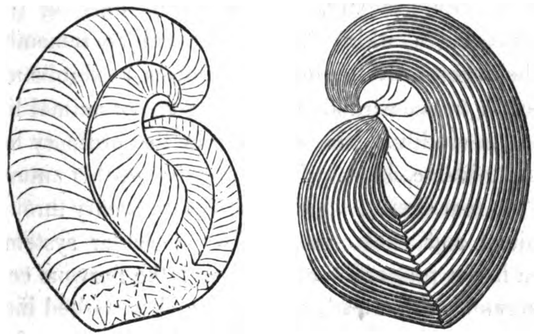
The annexed figure (11) represents a common and characteristic silurian species, of the kind afterwards most common; while the figures 12, 13, serve to illustrate the very remarkable internal partition, separating the interior of the shell into several parts in the case represented, and in other instances affording very singular modifications of this curious principle of structure. All the shells of animals of this group have projecting plates of shell, more or less prominent, passing up from the centre of the larger or upper valve. (See fig. 12.)

Fig. 11



Orthis.

Fig. 12 *Fig.* 13



Pentamerus.

The *Pteropoda* of the silurian formations were probably numerous and powerful, attaining a far larger size than they have done at any subsequent period. Several species of a genus (*Creseis*) still represented by some small Mediterranean species have been determined from some of silurian rocks; but of the habits of the animal we are not able to speak with any certainty. It is not unlikely, however, that they were exceedingly carnivorous, and supplied the place of the common tribes of univalve shells of after times.* They seem, also, to have preceded, in some measure, the cephalopods, and may, therefore, have performed the same part as the animals of this fierce and powerful group.

Of the true Cephalopoda there are several genera described from the rocks of the oldest period, and they differ chiefly in the shape of the singular many-chambered habitation, which is, in fact, the only part left by which we can identify these animals. They all bore a much greater resemblance to the nautilus than the cuttle-fish, and in this respect seem to exhibit the same peculiarity that has been already so often alluded to, namely, the usual introduction of groups of species possessing the lower organization of their tribe in the earliest formed strata of the earth.

The Nautilus (see fig. 52,) the lowest existing type of the Cephalopoda, which, however, it will be remembered, form the highest division of the Mollusca,) exhibits a great advance in the construction of the organs of animal life, by which it is readily distinguished from the ordinary inhabitants of univalve shells. In the first place, this animal has a true internal skeleton, and a perfect symmetry throughout the animal and vital organs. The muscular system also forms a larger proportion of the body; the nervous centres, concentrated in the head, have received a marked increase of bulk; the organs of the external senses are much more perfectly developed, and the respiratory tube has received an enormous development, and assists in propelling the cephalopod through the sea. The organs of locomotion and prehension are now arranged round the aperture of the mouth, which besides these possesses jaws working like the beak of a bird, and a strong spiny tongue. The organs of locomotion and prehension are, however, exceedingly simple and very numerous, differing in this respect from the more highly organized cuttle-fish.

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* The Gasteropoda themselves were not unrepresented in the seas of the earlier epoch, although they do not appear in the lowest rocks of all. There are at present sixty-three silurian species known—a number scarcely exceeding that of the Orthoceratites from the beds of the same age; while in the proportion of individuals whose fragments are found there is no comparison, the latter being far more numerous.

Lastly, in the shell we see a marked approach to a higher form of animal existence than is exhibited in other univalve shells. In the few animals enclosed in shells that are able to swim, we find the shell of very diminutive size, of simple form and structure, and of an extremely light and delicate texture. In the nautilus, on the other hand, we find a large, powerful, and complicated shell, composed of a number of separate compartments or air-chambers, all of them together forming a float, and enabling the strong and muscular occupant to rise at will to the surface of the water, or sink down into the depths of the ocean in search of the food of which it no doubt requires an abundant supply.

It is probable that the nautilus and its shell together are somewhat, though very little, heavier than water, when the animal has retired completely within its habitation. When, however, it expands itself and exposes a large surface beyond the aperture of the shell, and at the same time produces a slight vacuum in the last chamber, its specific gravity becomes on the other hand a little less than that of water, and it rises rapidly to the surface. It may also be the case that the curious tube, or siphuncle, that runs through all the chambers, assists in some way in thus adjusting the balance of the animal; although, from the appearance of this tube, coated with a thin calcareous deposit, it seems unlikely that its dilatation or contraction could produce any useful effect.* Contemporaneous with the various groups of animals already described, there seem to have been introduced in the primæval seas a large number of species very closely allied to the nautilus, but provided with floats or chambered shells not coiled into a spiral as is the case with the recent analogue, but either straight or very slightly curved; and from their resemblance to a horn, called by naturalists *Orthoceras** (or straight horn,) *Cyrtoceras* or (bent horn,) &c. The animals inhabiting these shells must no doubt have been very closely allied to the recent nautilus; but nothing is known of them except the fragments of their habitations, which exhibit great variety of form and some rather incomprehensible peculiarities of structure. Some of them appear to have been of great length and exceedingly slender; and the shell is often thin, although in that case the walls of separation between each two successive chambers are generally close together. The sides of the shell are often deeply ribbed or grooved, sometimes in the direction of its length, and sometimes across. A few of the species had their shells short and greatly swelled, having almost the shape of a pear; some again came rapidly to a pointed termination; and some were so nearly cylindrical, that it is difficult to suppose that they ever commenced at a point, and were increased by regular gradations. All these varieties of form are met with in the oldest rocks; and the large and important group of Orthoceratites, apparently the first, as it is the simplest form of the multilocular shell, seems to have attained its greatest development very early, and then was

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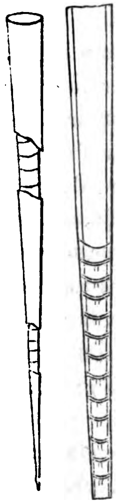
* Owen's Lectures on Comp. Anat. p. 327 et seq.

Figs.
14 15



ORTHOCERATITES.

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* Ορθος (*orthos*,) straight; κυρτος (*cyrtus*,) curved; and κερας (*ceras*,) a horn.

gradually replaced by other groups of Cephalopoda; until, towards the close of the first epoch, these animals had died out entirely, and were replaced by the nautilus, and yet more remarkably by the ammonites, which then appeared for the first time.

We have now gone through the description of the inhabitants of the seas during the earliest period at which the Geologist is enabled to trace the existence of living beings upon the earth. Let us, before concluding, briefly reconsider the results of geological investigation with regard to these ancient strata. In the first place, it is interesting to remark, that, among the groups exhibiting the lowest amount of organization, there are a few corallines, and a larger number of the stony corals. There are also several species of crinoids (lily-shaped polyps,) individually abundant; and although there appear to be one or two species of the more highly organized Radiata (such as the star-fish,) we very rarely find remains of other radiated animals than encrinites in the old rocks, although numerous higher forms afterwards became exceedingly abundant. Of the crustaceans again we obtain no fragments of true crabs or lobsters, or other common and known forms, but instead of them a group, long since extinct, not more likely to be preserved than the former, and, although for a time evidently very common, not continued into the middle one of the three great periods.

The absence or rarity of the common bivalve and univalve shells in these rocks is also a point of very considerable interest. A few species of the family represented by the common cockle (*Cardium*,) and a few also of the scallop tribe (*Pecten Avicula*,) both of which groups are remarkable among the shell-bearing animals for their locomotive powers, and the extent to which they adapt themselves to changing circumstances, are among the chief of the bivalves; and a number of species nearly allied to the carnivorous *Buccinum*, or whelk, represented in like manner the univalves. But although the genera now common were then so rare, their place was evidently supplied by two other groups now nearly lost sight of; and of these the vast number of shells allied to Terebratula, and the abundance of Orthoceratites, form the most striking and valuable examples.

Quite at the close of the period we are considering, a few small fishes, apparently allied to the shark tribe, were also introduced as typical forms of what should afterwards abound. Although, however, these fishes were introduced towards the close but before the termination of the period of the Invertebrata, it is important to remember that almost all the great natural divisions of the Invertebrata began at once and together to perform their work on earth; so that there is no appearance of any regular order of progression by which the encrinite succeeded the coral polyp, the trilobite the encrinite, the terebratula the trilobite, or the orthoceratite the brachiopod. All these seem to have been truly contemporaneous, and they were doubtless introduced as the group best fitted to perform the functions of their existence during the conditions, whatever they may have been, under which the world existed in their time. And so little in many points do the differences of their organization seem to require important changes in the temperature and atmospheric condition of the earth, so similar are the living species most nearly allied to them in all peculiarities of which we can fairly judge, that, however we may be inclined to conjecture and speculate on the probability of a higher and more uniform temperature, a more widely extended sea receiving similar deposits and containing similar species, or an atmosphere more highly charged with carbonic acid gas than at present,—these speculations must be kept within bounds, since the facts justify no more than the admission of their bare possibility.

The mere absence of certain groups or of certain species and genera afterwards common, is not the only point on which the naturalist dwells in considering the possible conditions of the ancient sea. It is much more important and much more interesting, to observe that these species were not only absent but that their place was supplied by other groups of animals analogous to them, having similar habits, but not identical in specific character.

Thus the place of the less highly organized of the common shell-fish, such as the muscles, the oyster tribe, and the like, was properly filled by numerous and varied forms allied to Terebratula (a lower group;) while the numerous groups of flesh-eating Gasteropoda (the Murex, the cone, the volute, the cowry, and many others) were equally well represented by innumerable orthoceratites (animals of higher organization), which then swarmed in the seas.

No doubt the appearance of these ancient seas would have appeared strange to the eyes of the naturalist, could an inhabitant of the world in its present state have become acquainted with the mysteries of the ocean's deep abysses at that time. With something of resemblance in the reefs and islands of coral rising gradually to the water's edge, as the coral polyp toiled and laboured from day to day and from year to year, there would yet be much more of difference both in the shallows and depths of the ocean. The former sometimes with a sandy, but more frequently a muddy bottom, would be peopled with countless myriads of those unsightly animals, the trilobites, swimming near the surface of the water with their backs downwards, looking out constantly, and sinking at the slightest approach of danger from beneath; while the remains of successive generations of these creatures, mixed with mud and sand, would rapidly form beds sometimes of great extent. From amongst such beds, or attached to the solid rock, would be seen, rising or leaning over on their short and slender stems, the simple forms of the crinoids or stoneflowers, more beautiful, perhaps, and more picturesque than the sea-anemones of our own coast, even when these latter are seen in all their beauty, and with their tendrils and fibres widely expanded and brilliantly coloured. The crinoids, wanting indeed the colour, but of far more elegant form, would some of them be seen spreading out their arms and fingers in search of prey, while others closed entirely their cup-like envelope,—giving a variety and life to the sea bottom, in spite of the cold, hard, stony frame-work of the animal, scarcely concealed by a living coat of leathery integument.

Besides these, and sometimes attached to them, every hard fragment of rock, and every hard surface at the bottom of the sea, at all moderate depths, would doubtless be overgrown with some one or other of the numerous family of Brachiopoda (Trilobites, &c.,) which we know to have been abundant. A few of the Conchifera (Pectens, &c.,) with their bivalve shells, might also be seen flitting about in the water, moving by jerks produced by the sudden shutting of their valves, but an infinite number and variety of other animals, swimming with much greater freedom and elegance, and of far greater size, then crowded the ocean, rising and sinking at pleasure, and with great facility. Some of these were of formidable dimensions, exhibiting a strange spear-like tail projecting downwards, and terminating above in a more or less powerful and sack-like body, moving with infinite rapidity in every direction; while others, short and almost globular, were perhaps less active, and sought their food in the little bays and inlets.

But there were then no fishes: these Cephalopoda were the lords and tyrants of that creation; they were the most numerous, the most highly organized, the least defended by stony or scaly armour, and the most powerful. Their long shell was probably not meant to shelter them from danger, and their whole appearance and character indicates that they were the attackers—not the attacked, and, like other powerful animals, were unprovided with defensive weapons, their vigour, strength, and activity answering this purpose sufficiently.

It is not for us to calculate how often our globe performed its annual course in the heavens between the commencement and the close of the long period which we have been considering in this chapter. We may conjecture, indeed, from the evidence before us in the fossil remains, and the order and condition in which they occur, that these revolutions must be counted rather by tens of thousands than by units; for during this lapse of time, whatever it may have been, many thousand feet of deposits were formed in various parts of the bottom of the sea, and each succeeding deposit, though only of a few inches, is provided with its own written story, its sacred memoranda, assuring us of the regularity and order that obtained, and of the perfect uniformity of plan. The changes that took place during this time were gradual and successive; the world of water was then being prepared, slowly but surely, for the reception of more highly organized beings, and, at length, although there is little appearance of physical alteration, the increasing abundance of these animals marks the commencement of a new period.

It is interesting to contemplate the probable conditions of the earth's surface and its physical features, as made known to us by these fossil remains; but in doing *so*, we ought to bear in mind constantly the true nature and value of the evidence. So far as it is positive—so far as we have only to make out the meaning of what we see—this is not difficult or doubtful; but when we begin to draw general conclusions, and speak of the absence of whole groups, because we do not discover any indications of their existence, we are reasoning from our own view of what, in all probability, and according to analogy, occurred, and not from positive data. Still, as the circle of our knowledge expands, and these conclusions, being tried by the test of experience, are found still correct, they do assume more and more the character of true generalizations, and become at length admitted as truths. I have here, and elsewhere in these pages, endeavoured to give fairly the result of all the evidence at present obtained on the subject, and have usually intimated the existence of a doubt where the amount of evidence seemed to me insufficient.

CHAPTER IV.

THE INTRODUCTION OF FISHES, THE CHARACTERISTIC ANIMALS OF THE SECOND FOSSILIFEROUS PERIOD.—THE DEVONIAN OR OLD RED SANDSTONE SYSTEM OF FORMATIONS.

It would seem that, during the whole period of the deposit of those many thousand feet of strata which make up the silurian series in Wales, Cumberland, and other parts of the world, there was no contemporaneous formation going on in the district now occupied by Scotland, or in that which at present forms the south-western counties of Cornwall and Devonshire in England. Further south, however, the silurian rocks are met with again, as in Brittany; and, as I have already mentioned, they exist in great abundance in various parts of Scandinavia, but owing to some cause, probably because those portions of the earth were then elevated above the level of the sea, and so were not capable of receiving any extensive additions, there does not appear to be in the British Islands any regular and complete passage from the slates and sandy beds of the older and non-fossiliferous period, to similar deposits immediately resting upon them. In Belgium, Russia, and Germany, such a continuity may be traced.

The existence of a break in the continuity of strata occurring thus early, and extending over an important geological period, but evidently local and confined to a small district, is a phenomenon well worthy of remark, and one which, when understood, will perhaps clear up many difficulties which have sometimes puzzled Geologists; but, before offering this explanation, it should be understood distinctly what is meant by calling an event of this kind a break in the continuity of strata or groups of strata.

If the animated beings who inhabit the different parts of the earth and sea had been at all times the same; if it were an indifferent thing to the marine animals whether they dwelt in shallow water, near shore,—in the deeper water of bays and other sheltered places,—in the open sea, near the surface, and where exposed to the constant action of the tides and currents,—or in the great depths of the ocean, far removed from land; and if species, thus cosmopolitan in their habits, had been introduced at the first creation of animals on the earth, and had succeeded one another in the regular order of nature, generation after generation repeating the same species; then, indeed, it would have been difficult, and often impossible, to determine whether the various strata lying over one another in any given spot were formed by continuous deposits, or with intervals between them of sufficient magnitude to allow of the interpolation of other beds in other places. But these conditions do not obtain in nature. It is well known to the naturalist, that, although some animals are much more capable of adapting themselves to changing circumstances than others, all species are more or less limited in their range, and that, in a vast proportion of cases, they are very strictly limited; a change of a few yards in the depth of the water, an alteration in the nature of the sea bottom or in the degree of exposure to tidal action, being quite enough to produce, at the present day, a marked difference in the appearance of the group of inhabitants of adjacent districts, which difference is perfectly appreciable at the first glance by one accustomed to observe with any degree of accuracy.

The general nature of the animal remains is not the only means possessed by the Naturalist, or made use of by the Geologist, to determine the circumstances under which submarine deposits may have taken place. There is now a chain of observations extending over the whole series of known strata; and, regard being had to the present advanced state of knowledge of the existing species of animals, it has been distinctly proved, that the more carefully and strictly these observations are compared and brought to bear upon one another, the more manifest is it, that, ever since the first introduction of animals upon earth, there have been successive creations of species similar to one another, but not identical,—performing often the same office, but perfectly distinguishable,—and involving a constant introduction of new species, although never, not even in a single instance, involving the repetition of a species that has once died out.

The statement of this fact, namely, that species, like individuals, have a certain limited term of existence, has already been made indirectly in the preceding chapter; and I have there described a number of animals very much unlike any that now exist, although not without such resemblances as indicate the possession of analogous habits, and exhibit proof of unity of design running through creation, and connecting even the most ancient species with those yet surviving; but I did not there speak concerning that peculiar succession of animals which the pursuit of Geology has proved to exist. It should, however, be clearly understood, that, in making use of this term "succession," I have no intention of assuming a gradual modification of species in the way of the development of a higher organization, as if animals originally created imperfect were subsequently, and by manifest gradation, at length enabled to perform functions of a higher kind; for this is by no means the case, so far as the observations of Geologists have hitherto been able to determine. The order of nature seems rather to be a succession of this kind; namely, that first of all, as we have seen in the last chapter, representatives were introduced of each of the principal natural subdivisions of the invertebrated animals, combining many typical characteristics subsequently kept separate, and that the species thus originally introduced were gradually displaced by others in which distinctness of typical character was more marked. Some animals, as the coral polyps, remained stationary in point of development; others, as the encrinites, lasted for a long time, but at length were partly superseded by higher types of the group, performing offices which required greater powers of locomotion; others, again, as the brachiopods, exhibited almost immediately the greatest abundance, variety, and extent of their development, and were only superseded, after a long interval, by the higher conchifers, which at first were sparingly introduced; while, again, others, (and those the most important in every respect,) such as the Cephalopoda, at once assumed an importance which hardly increased, although it varied, for a long period, and at length actually became less; these animals being ultimately succeeded by a group (the gasteropods) of much lower organization, although admirably fitted for the work they had to perform. We shall see hereafter that the course of development of the fishes and reptiles was very similar to this; so that there is no evidence of these animals having gradually passed into one another, or of any such order of succession having been a part of the plan adopted by the great Director of the universe.*

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* I have dwelt the more earnestly on this subject, because there appears to be a strong tendency in the minds of many persons to conclude, that since the Invertebrata appear to have been first introduced, and to have been in course of time succeeded by the vertebrated animals in something of the order of their organization, there was a succession and

Since it is the fact, that, according to some general law, species of animals are introduced, last only for a limited period, and are then succeeded by others performing the same office, it will readily be seen that in any group of strata the absence of a certain number of species common in beds of an older formation, and the presence in that group of other species which are analogous, would lead the naturalist to conclude either that a great change had taken place suddenly in the depth or relative position of the sea bottom receiving deposits, or else that a period had elapsed between the deposit of the lower or older beds and those which overlie them, and that this period was longer or shorter according to the amount of difference in the species examined. And this brings us to the subject referred to at the commencement of the present chapter, viz. the existence of a break in the continuity of strata observed in the case of the rocks of the second period in Scotland and Devonshire.

With regard to these localities, however, the evidence

a gradual development of higher types of existence in a certain order of creation. So far as Geology in its present state affords evidence on this subject, the facts seem decidedly opposed to any such view; and I make this statement the more unhesitatingly, because I find that it perfectly accords with the conclusions arrived at by one of the most philosophical of living naturalists, who brings to a close his investigation concerning the extinct Reptiles in the following manner:—

"Thus, though a general progress may be discerned, the interruptions and faults, to use a geological phrase, negative the notion that the progression has been the result of self-developing energies adequate to a transmutation of specific characters; but, on the contrary, support the conclusion, that the modifications of osteological structure which characterize the extinct reptiles, were originally impressed upon them at their creation, and have been neither derived from improvement of a lower, nor lost by progressive development into a higher type."—*Professor Owen's Report on British Fossil Reptiles; Report of Eleventh Meeting of the British Association at Plymouth*, 1842, p. 202.

requires a yet more detailed statement. In North Britain, the beds resting on and wrapping round the gneiss, the mica schist, and other old rocks, consist, for the most part, of coarse conglomerate or pudding-stone, evidently made up of the broken fragments of the old granitic rocks, rolled and tossed about for ages in a troubled sea, the hardest stones being rounded into bullet-shaped pebbles by their long and incessant attrition against one another. These coarse, gravelly masses are not, however, universal; and on the north-eastern coast and in the Orkneys they are often replaced by more regular strata of hard, dark-coloured, bituminous schists, abounding with the fossil remains of fishes.

On the frontier of Wales, a deposit, in many respects very similar to the conglomerate of Scotland, and expanded to an equal and enormous thickness, is found to cover up, by regular gradation, the newest strata of the silurian period; and from this deposit are obtained occasionally the fossil remains of fishes of the same species as those found in Scotland.

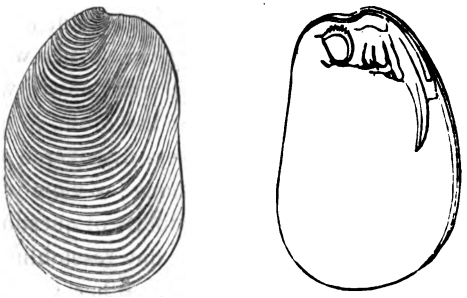
Lastly, in Devonshire and Cornwall, between the granite of Dartmoor and a series of black strata of the same geological age as the carboniferous beds which elsewhere overlie the conglomerate of Herefordshire and Scotland, there is a large series of sandy and slaty rocks, containing numerous fossil shells and other organic remains; and these appear, on examination, to possess a character intermediate between that of the silurian and that of the newer or carboniferous series.

Now it will be readily admitted, that a sea in which the coarse, gravelly conglomerates of Herefordshire and Scotland were being deposited, would be hardly likely to contain the remains of delicate shells and the skeletons of polyps and encrinites, because, even if the animals could have lived in such a sea, their hard parts would be ground and pounded into ten thousand atoms as soon as they were exposed to the rough beating of the shingles; while, on the other hand, the clayey and sandy bottom of the more southern sea might readily preserve such remains as were left by animals of this kind. It would not, therefore, be singular that we should find a number of fossils in the devonian beds very different from those in Scotland, even if they were being formed at the same time; and the evidence of contemporaneity offered, by comparing the fossils with those of beds whose position in the series was known, would be sufficient to establish the position of the group in question. In this way the devonian strata were discovered to be of the same date as the old red sandstone; a view which has since been verified beyond the possibility of question by the discovery, in Russia, of two series—one resembling our old red sandstone conglomerate, and the other our devonian gritty and slaty beds—both evidently belonging to one period—both fossiliferous, and each containing fossils, by which the identity of these rocks with the beds of our own country, both in Devonshire and Scotland, is placed beyond doubt.

In Belgium, and in other parts of Europe, the passage from the silurian rocks to those of newer date is perfectly unbroken; and even in Wales it is not easy, nor is it always possible, to distinguish so accurately between the two as to state where the lower series terminates, and which is to be considered the lowest member of the overlying group.

The line of demarcation between these strata being thus slightly marked in some places, the naturalist is enabled to trace the gradual transition of the animals characteristic of the one into those of the other series; but in the corals, the encrinites, the trilobites, and even in the shells, this is often difficult, although there is on the whole a considerable difference in the general appearance of a group of the fossil remains of Invertebrata taken from the upper and lower series of strata. An example of this difference is seen in the annexed figure of a remarkable bivalve shell (16, 17,) not uncommon in some of the rocks of the period we are now considering, but altogether confined to that period.

Fig. 16 *Fig*. 17



MEGALODON.

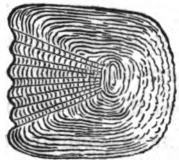
The peculiar form and magnitude of the hinge teeth (fig. 17,) and the beauty of the shell, render it worthy of notice.

But, although the differences of this kind are not such as need detain us here, there is another change of a far more striking character. I mean the introduction and speedy increase of the great natural class of fishes, whose remains

Fig. 18.

Ctenoid Scale—PERCH.

Fig. 19.

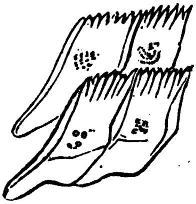


Cycloid Scale—EXTINCT SALMON.
(*Osmeroïdes Lewesienses.*)

are comparatively rare even in the uppermost silurian rocks, but which become extremely abundant in those beds immediately superjacent. The description of these fishes will be the chief subject of the remaining part of the present chapter.

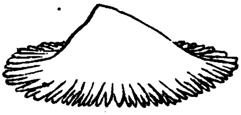
All the fishes at present known to exist in the waters which cover our globe may, with comparatively few exceptions, be grouped naturally and properly in two divisions, the one containing those species whose scales are jagged on the outer edge like the scales of the perch (fig. 18,) and the other those whose scales are smooth and simple at the margin, like the scales of a herring or salmon (fig. 19.) To the peculiarities thus alluded to, might be added many others derived from the minute anatomy of the fishes.

Fig. 20.



Ganoid Scale—Bony Pike.
(*Lepidosteus.*)

Fig. 21.



Placoid Scale—Extinct Ray.
(*Spinacorhinus polyspondylus.*)

The exceptions to this arrangement are comprised within a few natural families, of which the sturgeon, the Siluridæ or cat-fish, the bony pike of the North American lakes (fig. 20,) and some others, form one group; and the saw-fish, the rays (fig. 21,) and the sharks another. These two groups were naturally looked on as of comparatively small importance, so long as only the existing species of fishes were known, for they contain, with the exception of the sharks and rays, but very few species, and these are neither abundant nor widely spread.

When, however, it was discovered by M. Agassiz, on looking carefully at the numerous species of fish whose fragments are found fossil in the older rocks, that all these, without a single exception, belonged to one or the other of the two groups alluded to, it became necessary to reconsider the subject of the classification of fishes, and learn, if possible, the nature and extent of the difference that existed between those of the earlier seas and the present time.

The result of this, and the conclusions arrived at by a careful and minute study of the natural history and anatomy of fishes, has been lately laid before the public by M. Agassiz, a naturalist whose great acuteness of observation and knowledge of the structure of fishes, have long been well known to the scientific world, and were appreciated by Cuvier, who left in his hands the papers he had himself accumulated on the subject of Ichthyology.

According to M. Agassiz, fishes may be collected into four natural orders, two of which have been already mentioned as including most of the recent fishes, while each of the other two groups, so rarely met with at present, contains species representatives of another order, equally important and well marked, and in former times represented almost to the exclusion of any species of the two orders now so abundant. The first of the two groups, that of which the sturgeon and the bony pike are characteristic, is called GANOID; while the other, containing the sharks and rays, is known as the PLACOID order.* Of these, the Placoid seems to have been the first introduced, but the Ganoid was that which attained its greatest development in the ancient seas.[*]

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* *Ganoid*, from the Greek γανος (*ganos*,) splendour; the scales of these fishes being generally coated with polished enamel, and often exhibiting a very brilliant lustre. *Placoid*, from πλαξ (*plax*,) a plate or slab; because the skin of the animals of this order is irregularly covered with plates, studded often with enamel. (See figures 20, 21.)

The tribe of existing Placoid fishes most resembling those whose remains are found fossil, is that of which the sharks are the well-known representatives. These powerful and rapacious animals, which are at this day the tyrants of the deep, seem to have been, when first introduced, of small size, and were accompanied by some few species of the next or Ganoid order. Only nine species of these shark-like monsters have yet been determined with certainty from the silurian and devonian rocks; and of these, two only are from the former.

It is chiefly the Ganoid fishes whose remains are handed down to us in the old red sandstone and other rocks of that period. Sixty distinct species of these fish have been mentioned and almost all of them are known from British specimens. Most of them are remarkable for exhibiting strange peculiarities of shape, approximating them in some instances to the structure of the lower order of animals, combined with some apparent affinities to the class of reptiles.

The most remarkable group of these fishes contains several genera, three of which will require special notice. They are the *Cephalaspis* (or buckler-headed, fig. 22,) the *Pterichthys* (or wing fish, fig. 23,) and the *Coccosteus*[†] (fig. 24,) so called from the berry-like tubercles with which its bony scales are covered.

The most extraordinary part of the first of these fishes,

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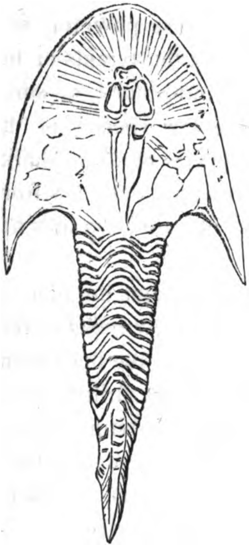
[*] The remaining two groups are called respectively *Ctenoid* (κτενος, *ctenos*, a comb) and *Cycloid* (κυκλος, *cyclos*, a circle,) from the shape and structure of the scale. (See figures 18, 19.)

[†] All these names are derived from the Greek. They are thus obtained:—Cephalaspis, κεφαλη, (*cephale*,) a head; ασπις (*aspis*,) a shield or buckler. 2. Pterichthys, πτερον (*pteron*,) a wing; ιχθυς (*ichthys*,) a fish. 3. Coccosteus, κοκκος (*coccos*,) a berry; οστεον (*osteon*,) a bone.

"the buckler-headed," is the head from which its name is taken. This has been compared* to the crescent-shaped blade of a saddler's cutting-knife, the body forming the handle. It is extremly broad and flat, extending on each side considerably beyond the body, and the bones appear to have been firmly soldered together, so as to form one shield, the whole head thus being apparently covered by a single plate of enamelled bone, and when seen detached from the body hardly to be distinguished from the head of a trilobite. The body compared with this singular head appears extremely diminutive; the back is arched and gradually recedes in elevation towards the tail, which is of moderate length; the fins are few in number, and not very powerful, but appear to have possessed a bony ray in front, the rest of the fin being more fibrous. The whole body was covered with scales, which varied in shape in different parts, and seem to have been disposed in series. This fish never seems to have attained a large size; the best preserved specimen having a length of only seven inches, with a breadth of three inches between the points of the cresent-shaped buckler. It has been supposed by Professor Agassiz that the singular shape of the head served as a sort of defence to this animal in case of attack; and

Fig. 22.



Buckler-headed Fish.
(*Cephalaspis.*)

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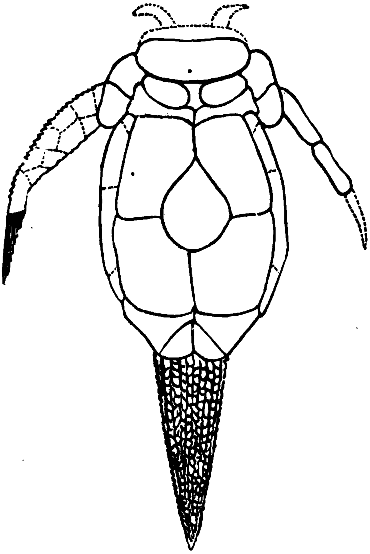
[*] The Old Red Sandstone; or, New Walks in an Old Field, by Hugh Miller, p. 138.

one can readily imagine that the soft substance of the orthoceratites, probably the largest and most formidable of its enemies, would be injured by any attempt to swallow so singular and knife-like an animal as the one before us.

Like many, and indeed most of the species belonging to the Ganoid order of fishes, and common in the older rocks, the bones of the head, and the scales of this strange monster, were composed internally of a comparatively soft bone, but each was coated with a thick and solid plate of enamel, of extreme hardness, and almost incapable of injury by any ordinary amount of violence. The detached scales, the buckler-head, and sometimes the complete outline of the animal, have thus been able to resist destruction, and are found in sandy rocks, composed of such coarse fragments that their accumulation would seem to have been accompanied with violence sufficient to have crushed to powder almost any remains of organized matter, and from which, indeed, we never obtain any fragments of shells or other easily injured substances. The remains of this fish have been found in Herefordshire and many parts of Wales, as well as in Scotland, and lately also in Russia; but the animal was strictly confined to the period of the old red sandstone, though it is not easy to guess what may have been its habits, in what depth of water it preferred to live, or in what way it obtained its food.

The *Pterichthys* (fig. 23) is even more strikingly different from any existing species of animal than the singular monster we have just been considering. Reverting to the graphic description of Mr. Miller, we find it compared to the figure of a man, rudely drawn, the head cut off by the shoulders, the arms spread at full length as in the attitude of swimming, the body rather long than otherwise, and narrowing from the chest downwards, one of the legs cut away at the hip-joint, and the other, as if to preserve the balance, placed directly under the centre of the figure, which it seems to support.* Something of this appearance is indeed presented in the fossil remains of these creatures, once the tenants of the sea in our own latitude; but we are now able to describe with more minuteness, if not so vividly, the real nature of the animal. It was of small size, not more than a few inches or a foot in length; its head and body were defended by strong plates of bone coated with enamel; and its shape and proportions were singularly unlike those of ordinary fishes; the head being small, and the body much flattened, but swelling out immediately at the junction of the head and neck, and gradually tapering thence towards the tail.

Fig. 23.



Horned wing-fish. (*Pterichthys cornutus.*)

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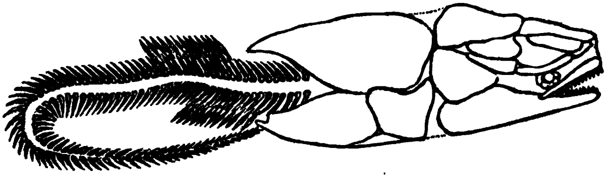
* Miller, *ante cit.*, p. 49.

From the junction of the head and body there extended that pair of singular paddles or wings from which the genus has been named, and which have been supposed to answer the same purpose as the horns of the crescent-shaped shield of the Cephalaspis, and defend the animal from the attacks of its soft-mouthed enemies. Besides these paddles, which were hard and pointed, and nearly as long as the body, at least some species of Pterichthys seem to have been provided with another smaller pair, extending from the part where the body is attached to the tail; and it is thought that this second pair of wings may be the remains of anal fins, the other pair representing the pectoral fins. The body, like the head, was certainly covered on the upper side by hard plates accurately fitting one another; but the lower part both of the head and body was probably defended by tough skin, capable of distention, and enabling the creature to swallow prey of large size. The position of the mouth is not known with certainty, but it may have been formed by a transverse slit, covered by thick fleshy lips, situated round the edge of the plate which defended the head; this position, and the absence of teeth, readily accounting for the difficulty there is in discovering remains of it in imperfect specimens. The eyes and the apertures of the nostrils were probably extremely small, and placed on the edge of the broad plate, the only indication of the head hitherto met with. The tail was not long, but seems to have been thick and conical, and covered with scales, overlapping each other like the tiles on the roof of a house.

The departure from the general form of most fishes in this animal is so remarkable, that when first discovered, it was looked upon by some naturalists as an insect, by others as a crustacean, and by others again it was thought to be connected with reptiles, owing to the singular resemblance of one small species to the shell of a tortoise. Strange as it undoubtedly is, however, in all respects, this genus forms one of an extinct natural family of fishes, and it is allied to the other genera of its class by the genus *Coccosteus*, which at one time was thought still more anomalous.

Fig. 24.



COCCOSTEUS.

The Coccosteus (fig. 24) is entirely without the wing-like projections which characterize the Pterichthys, and while when seen as in ordinary specimens, lying on its back and crushed, it appears to bear no resemblance to any fish or other animal either recent or extinct, it was not in reality much unlike many well-known fishes in its general outline, although so oddly coated with large broad plates, which were studded with enamel, instead of scales.

The head of the Coccosteus was large, broad, and high, nearly circular in shape, covered by several plates, and attached to the body by a very small articulating surface, resembling in this the insects, and departing widely from the fishes. The jaws are large in proportion, and armed with very strong pointed teeth, the mouth opened as in the cod and other well-known fishes, and no doubt rendered the animal sufficiently formidable; and the lower part of the head seems to have been covered with a tough membrane, capable of distention, and enabling the animal to swallow very large bodies. The upper part of the body was chiefly covered by one large plate, and the lower part by four plates of rather curious shape. The tail was large, and much longer than the body, and was provided with two small fins. The detached plates, more especially those which covered the body, are frequently found fossil in certain localities of the old red sandstone.*

The fishes just described form together one of several groups characteristic of the period we are now considering. But another group also, containing four genera, is worthy of notice, as contrasting strongly with the Cephalaspides (as the former are called;) and, instead of being clothed with large plates, these are recognised by the extremely minute scales with which the fish belonging to it are covered. These scales give to the skin an appearance very strikingly resembling that of shagreen.

The size of the fishes thus brought together is generally small, and their shape is squat and awkward, the head being large, and the body dwindling away to a very small tail: they have, however, large teeth, and must have been powerful, if not very rapid fishes. Their fins offer some peculiarities, being formed of a multitude of delicate-jointed rays, generally terminated by one very powerful ray or spine, sometimes simply planted in the flesh, sometimes articulated to bone. Both this group and the former are entirely confined to the first epoch, and almost entirely to the particular period of the old red sandstone.

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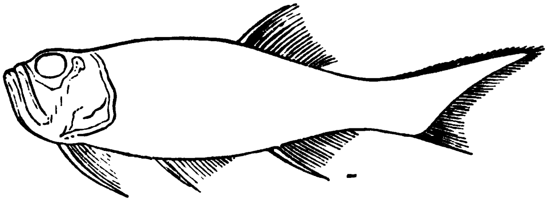
* Besides the Cephalaspis, Pterichthys, and Coccosteus, there is a fourth genus belonging to this group, which bears, however, so near a resemblance to the Pterichthys as not to require a separate description in this place.

Caithness and the Orkneys, Cromarty and Lethen Bar, Gamrie and Dura Den in Fifeshire, are all well-known localities for old red sandstone fish. Some species, exceedingly rare in other places, are met with in Forfarshire, and in general the different groups are distributed in special localities. The remains of fishes referable to the same species occur also in Herefordshire, and have been found in Russia, where, indeed, fragments belonging to one animal of this kind (*Chelonichthys*, or Turtle-fish) are of gigantic size.

Another group of these ancient fishes (*Dipterians*,*) is remarkable for the great magnitude to which the fins were developed, and the fact that in all of them the fins on the back and below the tail are double. The jaws of these animals were provided with sharp-pointed teeth; the head was enclosed as if in a box of cartilage, coated with anamel; and the scales of the body are in some species so large as not to have required more than about half a dozen to reach from head to tail (*Glyptolepis.*) This, however, was by no means a general character, and the presence of prominent spines supporting and defending the fins is probably more essential. The annexed figure (25) represents one genus in which these spines are beautifully exhibited in connexion with very minute although perfectly ganoid scales. It is probable, that almost if not all the fishes of this family of dipterians were more rapid swimmers and more voracious than those of the former two families. They are all, however, of small size.

Fig. 25



SPINE-FINNED FISH. (*Chiracanthus.*)

Besides these there is another family, chiefly developed in the latter part of the period, and attaining a larger size. One of the members of this group has been named *Holopty-*

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* Δις (*dis*,) twice; πτερον (*pteron*,) a fin: double-finned.

chius,* and is confined to the devonian period. Its head was small compared with the size of the body, whose proportions were so robust and its covering of large rounded deeply-wrinkled scales on so grand a scale as almost to deserve being called gigantic. The actual dimensions of the body in one complete specimen measure thirty inches by upwards of twelve. The jaws were of bone, coated with naked enamel; a row of thickly-set pointed teeth fringed the lips, and within this row was another whose bulk was at least twenty times as great. The other genus (*Megalichthys*) was perhaps more strikingly characteristic of the next succeeding period, during which the carboniferous limestone and coal were being deposited, and it may therefore be as well to postpone for the present any description of it.

On the whole, it appears, then, that this second period is at least as remarkable for the number and variety of the remains of fishes found in the beds which represent it as the former was for the fragments of corals, shells, and other animals of inferior organization. There seems at present no reasonable way of accounting for this but by supposing, that, until a certain time, commencing in England with the mud-stones of the silurian rocks, fishes had not been introduced upon the earth, and that when introduced they were at first few, and afterwards increased both in number and variety. The fact, however, that among the forms of these animals first met with we have several representatives of the tribe of sharks, and also of some of the bony fishes of singular complexity of organization,† is a sufficient answer to any idea that might be entertained of a gradual advance towards perfection of structure, even if we did not see in the order of their introduction ample reason to disprove any such notion. The singular family containing the Pterichthys and Coccosteus, now that it has been fully examined, exhibits also no approach in structure and but little analogy to the lower tribe of Invertebrata.

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* From ολος (*holos*,) the whole; πτυχη (*ptychê*,) a wrinkle or fold. The whole surface of the scales being covered with deeply marked wrinkles.

† Agassiz, Monographie des Poissons Fossiles du Vieux Grès Rouge, p. 32.

CHAPTER V.

THE APPEARANCE OF LAND AND THE INTRODUCTION OF LAND VEGETABLES.—THE CARBONIFEROUS SYSTEM.

THE period of the silurian rocks and the old red sandstone may then be considered to include the muddy and sandy beds which have now become changed into imperfect slates in Devonshire and the northern part of Europe—the coarse pudding-stones of Herefordshire, Scotland, and Russia—the mudstones and muddy limestones of ancient Siluria—the slates of Wales and Cumberland, and the numerous and varied strata of the same age in other parts of the world. It thus presents, on the whole, a vast natural group of strata, possessing considerable uniformity of character, and not difficult to recognise; and although often infinitely varied in appearance, even in the same locality, it more properly deserves to be called a universal formation than any other that has come under the notice of Geologists.

This uniformity of character is worthy of notice, because, after the conclusion of the period in question, a great change seems to have taken place in almost all parts of the world.

One result of this change is seen in the preponderance of carbonate of lime over every other form of submarine deposit during this next period, and in the sudden and remarkable abundance of vegetable fossils, indicating not only the presence of land, but the existence of a luxuriant and *quasi* tropical vegetation, permitting the accumulation of thick and widely-spread beds of coal, which occupy basin-shaped depressions in the limestones and sandstones, and which, although more especially abundant in the central parts of North America and in our own island, are recognised also in eastern Europe, on the Donetz; in various parts of Asia; and in eastern Australia and Van Diemen's Land.

It must not be supposed, however, that any considerable proportion of the rocks of this, which is generally known as the carboniferous, or coal-bearing period, is actually made up of the remains of vegetable matter. The first of the series of strata thus deposited seems to have been, in most parts of the world, a solid compact limestone, almost the whole of which is sometimes the result of the labours of the coral insect; and although there are also beds of limestone in the more ancient part of the first great series evidently formed by these little animals, yet these bear no proportion whatever, either in extent of surface or in thickness, to the coralline limestones of the newer period we are about to describe. In the British Islands it would appear that the most considerable masses of limestone were formed immediately after the deposit of the old red sandstone and devonian rocks had been completed; but we have distinct evidence in the gradual diminution in the size of the pebbles, and at length the alternation of limestone with fine marine gravel, that there was neither a sudden change nor a break in the continuity of depositions. It is probable, therefore, that, at the time thus indicated, there may have existed in our latitudes a shallow sea bottom, well adapted in some places for the foundation of coral reefs, and probably resembling the shallows upon which similar circlets of coral islands have been built in the Pacific Ocean. Upon such banks, and on a sinking continent, the coral animals of the ancient seas seem gradually but steadily to have reared their eternal monuments of labour. and thus there grew up in the course of ages those numerous and often detached, but always similar limestones, which may be traced very readily both in the British Islands and in other parts of the world. In our own country they extend from South Wales and the neighbourhood of Bristol northwards, bearing a little to the east, and although often covered up by newer beds, they still form the predominating rocks in the counties of Derbyshire, Lancashire, Yorkshire, Durham, and Northumberland. To the west the same rock recurs, possessing all its most striking features; and though only exposed in certain limited districts, yet it exists over the greater part of Ireland, although there, as in many parts of England, it is frequently covered up or replaced by a coarse sandy grit, unlike the old red sandstone, and generally known amongst Geologists as the *millstone grit*.

Whilst the coral limestones were thus being built up in the seas which then covered our island, there seems to have been a tract of land extending to the west, ranging both north and south from England, and also from the western coast of what is now Ireland. In evidence of this, we find that the lowest beds of the carboniferous period in the north-west of Yorkshire, in Devonshire, and also in some parts of Ireland, abound with the remains of land vegetables; and, although there is no doubt that many of these may have been drifted by marine currents, there is, at all events, great probability of the distance from land not having been great.

It is worth noticing also, with regard to this point, that the carboniferous limestones, or corresponding beds of the same age, skirt the old rocks of Cumberland, and are deposited in hollows in the devonian rocks of Devonshire and Cornwall; and it is likely that these very rocks themselves, as we know them to have been hardened and prepared for such exposure, formed the actual dry land of the period, and that upon them grew the trees and shrubs whose remains are met with in the limestones near them. However this may be, the existence of adjacent land at this time is sufficiently proved; and we may proceed to consider the circumstances of the deposit of the coarse grit and finer sandstones, the upper members of which were the receptacles of the great masses of vegetable remains now changed into the mineral we call *coal.*

It is not improbable, or contrary to what we have reason to think the usual order of nature at present in those parts of the world where coral formations are in progress, that the building up of extensive reefs, of great thickness and extent, should be succeeded by a change in the level of the neighbouring sea bottom. In the case of the carboniferous rocks, this change probably involved the depression of a large tract of land, of whose general form and even direction we are quite ignorant; nor can we even assert positively, with regard to this land, whether it consisted of numerous small detached islands, or of an archipelago with a few large islands, such as we now have off the eastern coast of Asia. But this depression was most likely succeeded by elevation; and in whatever direction the new land appeared, there are distinct indications of the deposit of very thick and extensive beds of sandstone and grit having preceded those muddy and fine sandy beds in which the vegetable remains were chiefly preserved, and which handed them down in vast abundance to the later days of our earth's history.

These unfossiliferous sandstones are chiefly exhibited in the northern, though they are not absent in the southern part of the great expanse of the carboniferous rocks in England; and they also cover almost the whole of the mountain limestone of Ireland. Some parts of the middle of England exhibit no traces of them; and the condition of the south Staffordshire coal-fields, where the limestone is also absent, and the coal-measures rest immediately on the old rock, offers ample proof of the partial character of the deposit, even if the very nature of coral reefs and Islands did not render probable the occasional absence of one member of the series. It is, however, worthy of notice, that in this middle district, where sometimes the mountain limestone and sometimes the coarser grits are absent, we find a thin but very well-marked band of pale blue limestone, not coralline, but of distinctly fresh-water origin, belonging to the upper and newer beds of the coal-measures, and appearing at intervals over an area whose extreme points are nearly a hundred miles apart.

Those parts of the great carboniferous series which generally include the beds of coal consist of muddy and sandy beds, alternating with one another and with the coal itself. Some of them would appear to be of fresh-water and some of marine origin; and they abound, for the most part, with remains of the leaves of ferns and fern-like trees, together with the crushed trunks of these and other trees, whose substance may have contributed to form the great accumulations of bituminised and other vegetable carbon obtained from these strata, and well known under the name of coal.

It is not easy to communicate such an idea of beds of coal as shall enable the reader to understand clearly the nature of the circumstances under which they may have been deposited, and the time required for this purpose. The actual total thickness of the different beds in England varies considerably in different districts, but appears to amount, in the Lancashire coal-field, to as much as 150 feet. In North America there is a coal-field of vast extent, in which there appears at least as great a thickness of workable coal as in any part of England; while in Belgium and France the thickness is often much less considerable, although the beds thicken again still further to the east.

But this account of the thickness of the beds gives a very imperfect notion of the quantity of vegetable matter required to form them; and, on the other hand, the rate of increase of vegetables, and the quantity annually brought down by some of the great rivers, both of the eastern and western continents, is beyond all measure greater than is the case in our drier and colder climates. The trees which, in many cases, contributed largely to the formation of the coal, seem to have been almost entirely succulent, and capable of being squeezed into a small compass during the partial decomposition. This squeezing process must have been conducted on a grand scale, both during and after the formation of separate beds, and each bed in succession was probably soon covered up by muddy and sandy accumulations, now alternating with the coal in the form of shale and grit-stone. Sometimes trunks of trees caught in the mud would be retained in a slanting or nearly vertical position, while the sands were accumulating round them; sometimes the whole would be quietly buried, and soon cease to exhibit any external marks of vegetable origin.*

To relate at full length the different processes, and the gradual superposition of one bed upon another, by which at length, and by slow degrees, the whole group of the coal-measures was completed, would involve far too much complication of detail to be described in a few pages; and when it is remembered that the woody fibre, when deposited, had to be afterwards completely changed, and the whole character of the vegetable modified, before it could be reduced to the bituminous, brittle, almost crystalline mineral now dug out of the earth for fuel, it will rather seem questionable whether the origin of coal was certainly and necessarily vegetable, than reasonable to doubt the importance of the change that has taken place, and the existence of extraordinary means to produce that change. Nothing, however, is more certain than that all coal was once vegetable; for in most cases woody structure may be detected under the microscope, and this, if not in the coal in its ordinary state, at least in the burnt ashes which remain after it has been exposed to the action of heat, and has lost its bituminous and semi-crystalline character. This has been too well and too frequently proved by actual experiment, to require more than the mere statement of the fact.

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* There can be no reasonable doubt, judging from the analogy of existing vegetation, that some beds of coal may have been derived from the mass of vegetable matter present at one time on the surface and submerged suddenly. It is only necessary to refer to the accounts of vegetation in some of the extremely moist warm islands in the southern hemisphere, where the ground is occasionally covered with eight or ten feet of decaying vegetable matter at one time, to be satisfied that this is at least possible.

The principal vegetable remains, the study of which conducts the botanical fossilist to a knowedge of the trees and shrubs, that clothed the land during this period, are not met with in the substance of the coal itself, but in the shales and sandstones so abundantly mixed with the coal. These beds have received, and occasionally retained, the fragments that have been deposited in them; and from such fragments, consisting of leaves and small branches, portions of the larger branches, or even the entire trunk, and occasionally, also, internal casts or markings of the surface of the fruits of various trees, conclusions have been arrived at and analogies drawn expressing the relation they bear to existing plants. Now if, in all cases, the solid substance of the trunks and the perfect outline of the leaves and fruits had been preserved, the botanist might fairly have been expected to explain the general character of the vegetation thus exemplified; but unfortunately this is not the case. In most instances, even those which seem most favourable, it is only the cast of the tree in sandstone, the impression made by the outside or inside of the bark, and a little of the substance of the bark turned into coal, that remains; and the shape even of the trunk has been often completely lost by crushing; thus showing, indeed, one peculiarity indicative of the great natural group of trees to which the fossils belonged (the Monocotyledons, or Endogens,) but at the same time almost precluding the possibility of comparison with the few recent plants of the same tribe which appear to resemble them in general form or structure.

Still, in spite of the difficulties with which the subject is surrounded, and in spite of the perplexing confusion which might well alarm the botanist only acquainted with the ordinary marks of distinction exhibited by plants, a great deal has been done towards determining the general nature of the flora of the islands of the carboniferous period. It is remarkable, that, in the first place, this flora is found to be, to a great extent, uniform in all parts of the globe from which carboniferous fossils have been obtained;* and, in the next place, that, if we wish to compare this ancient flora with those which bear resemblance to it at present, either in the general preponderance of particular plants, or in the total absence of others, we must leave entirely the northern latitudes and the northern hemisphere, and transport ourselves to the islands in the neighbourhood of our antipodes, where New Zealand and the southern part of Australia, together with an innumerable multitude of small islands, form almost the only land that now exists in the vast area between the tropic of Capricorn and the South pole.

But although in such distant parts of the world we really have a somewhat similar group of plants to that of the coal-measures, and the dark-tinted ferns do now, as they once did in the northern hemisphere, take the place of our cheerful grasses, and even grow in rank luxuriance into forest trees, being associated with palms and some peculiar pines, there is probably after all but little true resemblance; nor can the Geologist feel satisfied that the condition of things was the same formerly in England as it is now in the islands of the southern sea. One of the most remarkable peculiarities of the coal fossils certainly is, however, the singular preponderance of the tribe of ferns already alluded to, and the great variety of form in which plants of this kind are developed. Of these forms, the annexed figures (26, 27) represent two that are common and highly characteristic. They are found sometimes in isolated fragments, in sand or shale, but are sometimes so very abundant, that the whole mass seems to have been formed rapidly in association with such vegetable remains.

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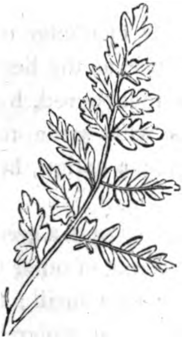
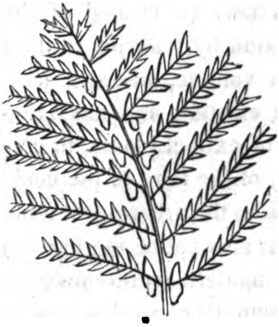
* Namely, the whole of western, northern, and eastern Europe, North America from Alabama to Melville Island, various districts in Asia, eastern Australia, and Van Diemen's Land, and (probably) the Asiatic islands.

Fig. 26



PECOPTERIS.

Fig. 27

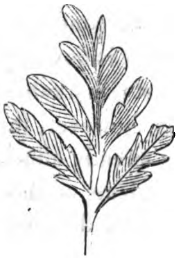


ODONTOPTERIS.

Besides these two forms, there are, however, many others; as, for instance, the *Sphenopteris* (fig. 28,) and the *Neurop-*

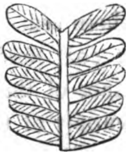
*teris** (29;) both of them common, and, in all probability, belonging to the group of arborescent ferns, and growing in wild luxuriance on stems of greater or less altitude. Some notion may be formed of the peculiar character of such vegetation by referring to the frontispiece at the beginning of this volume, where it has been endeavoured, by combining existing and analogous forms with some restored forms of extinct plants, to communicate a notion, however vague, of the flora of the coal period.

Fig. 28



SPHENOPTERIS.

Fig. 29



NEUROPTERIS.

Besides the arborescent ferns, then growing to a great size, I might also notice the gigantic proportions of other plants, whose modern representatives are uniformly small; but, as the resemblance in this case is simply one of general form, and the great majority of other trees seem to possess no living type to which they can be referred, it is by no means impossible that these also may be completely lost. One example of them is seen in a plant, fragments of which are extremely common in the coal-measures, and which has been called *Calamite** (fig. 30.)

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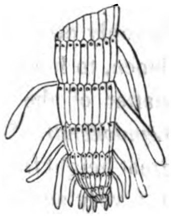
* These names are all derived from the peculiar form of the leaf and its venation, in combination with the Greek word πτερις (*pteris*,) a fern. The derivatives are respectively πεκω (*peco*,) to comb; οδους gen. οδοντος (*odontos*,) a tooth; σφην gen. σφηνος (*sphenos*,) a wedge; and νευρον (*neuron*,) a nerve.

The remains of calamites consist of jointed fragments, which were originally cylindrical, but are now almost always crushed and flattened. They resemble very closely, in general appearance, the common jointed reed growing in marshes, and called Equisetum, or mare's tail; but, instead of being confined to a small size, they would seem to have formed trees having a stem sometimes more than a foot in diameter, and jointed branches and leaves of similar gigantic proportions. They were evidently soft and succulent, and very easily crushed. They seem to have grown in great multitudes near the place where the coal is now accumulated; and, though often broken, they seldom bear marks of having been transported from a distance.

Fig. 30



CALAMITE.

The calamites, although common fossils in the coal-measures in all places where those rocks appear, are by no means so abundantly present as the fronds or leaves of ferns; and these latter seem, as has been already observed, to have belonged to that tribe of ferns, species of which grow to a great height and on a lofty trunk, forming what are called tree ferns, well known in the Australian Islands and colonies, and met with also in other countries where the conditions of vegetation are equally favourable for these plants.

There is nothing in the appearance of such leaves or their structure which distinguishes them very especially from the ferns of a later period or of the present day. Their great preponderance over all other fossils in the shales, proves how large a proportion they occupied of the whole flora, or

* Καλαμος (*calamos*,) a reed.

at least of that portion capable of preservation; and the presence, also, of stems and trunks, marked with scars like those observed on modern tree ferns, shows that, like these, they attained a very large size, and grew in a very similar manner.

Two well-marked genera of lofty forest trees are almost the only other plants, which appear, from their great abundance, to have contributed in large proportion to the solid matter of the coal. Of these, one, called by Geologists *Lepidodendron** (see frontispiece,) seem to have risen to a great height from the ground, and to have given off branches at a very acute angle. The whole stem was covered with scars, or marks of the places from which leaves had fallen, and the leaves or fronds themselves seem to have been borne in long rows, arranged in a different manner from that observed in existing trees. The most probable account of this tree is, that it bore a considerable resemblance in some respects to a particular group of pines, but that it exhibited in other matters, and those too of great importance in classification, analogies with the singular club-mosses (*Lycopodiaceæ,*) so close as almost to justify the opinion of its having formed a connecting link between these two very different natural tribes of plants.

Another genus, the *Sigillaria*† (fig. 31,) must, if recent observations are correct, be considered as the stem of the tree of which the so-called *Stigmaria*‡ was only the root. It was even more abundant, and a still more important element in the formation of coal, than the Lepidodendron.

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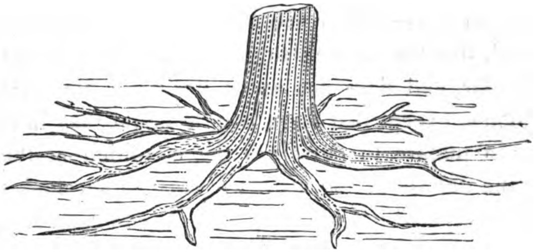
* *Λεπις*, gen. *γεπιδος* (*lepidos,*) a scale; *δενδρον* (*dendron*) a tree: the trunk of this tree being marked along its whole length with scales or scars.

† From the Latin *sigillum*, a seal, or the impression made by it; the trunk of the tree appearing to have been stamped with a pattern in regular rows along the direction of its length.

‡ *Στιγμα* (*stigma,*) a mark. The fossil was called Stigmaria, from the regular and deep marks or brands impressed on the supposed stem or root.

The stems of Sigillariæ exhibit no internal woody structure, having been for the most part either hollow or succulent, and easily crushed, but they were evidently provided with a central woody axis, and also with an outer coating of bark, the latter ofter turned into coal, and sometimes being nearly an inch in thickness. The whole of the trunk is elegantly fluted, and there is a single row of small scars, the remains of leaves, at regular distances on each fluting. It is pretty clear that the leaves attached at these scars were connected through the bark with the central woody axis.

Fig. 31.



Sigillaria.—Trunk and Roots.

The fossils that have received the name *Stigmaria*, and which have been supposed to be roots belonging to Sigillaria, are in some places so extremely abundant in the shales lying under coal seams, that in South Wales they seem almost invariably to form a kind of floor on which the coal rests. In this case the slender fibres proceeding from the large roots are completely matted together, and form an entangled mass, traversing the bed in every direction. Like the Sigillaria trunk, these roots appear to have consisted of a tough bark enclosing a woody centre, the interval being filled with succulent matter. The plants thus described probably belonged to an extinct family, intermediate in character between the cone-bearing plants or pines and the Cycadææ, and they probably resembled the Zamia, although expanded into a lofty forest tree, and giving off branches as well as leaves.

But while such is the nearest approach that we can make to a description of their appearance, it must not be imagined that we have arrived at any very certain conclusions with regard to these vegetables. They appear to depart so widely from those which are now common in any part of the world, that we can only suggest what may perhaps have been similar, and dare not assert positively the existence of analogies, except that there is little doubt that in endeavouring to picture to ourselves the condition of the land during the deposit of the coal, we must rather look to the southern antipodal islands, and especially to New Zealand, for these analogies, than to other parts of the world where vegetation, although even more luxuriant, belongs to a different type.

And there is, after all, nothing improbable in the notion, that, at the period of the deposit of the coal-measures, the northern hemisphere in our latitudes was for the most part occupied by a great ocean, studded over with numerous islands, some of larger, some of smaller size; open water reaching from this archipelago quite to the arctic circle. Innumerable Islands and reefs may have been there planted and destroyed, while some few, undergoing depression at a slow rate, became before their final disappearance the receptacle of those sandy and muddy banks among which the vegetable matter was embedded. Numerous inlets may have indented the coast line of the larger islands, and have received into them rivers or mountain streams, loaded with the fragments of trees and other vegetables brought down during the rainy season.

The whole of the interior of the Islands may have been clothed with thick forest, the dark verdure of which would only be interrupted by the bright green of the swamps in the hollows, or the brown tint of the fern covering some districts near the coasts. The forest would have been formed by a mixture of several different trees. We should see there, for instance, the lofty and widely-spreading Lepidodendron, its delicate, feathery, and moss-like fronds clothing in rich luxuriance branches and stems, which are built up, like the trunk of the tree-fern, by successive leaf-stalks that have one after another dropped away, giving by their decay additional height to the stem, which might at length be mistaken for that of a gigantic pine.

There also should we find the Sigillaria, its tapering and elegant form sustained on a large and firm basis, enormous matted roots almost as large as the trunk itself being given off in every direction, and shooting out their fibres far into the sand and clay in search of moisture. The stem of this tree would appear like a fluted column, rising simply and gracefully without branches to a great height, and then spreading out a magnificent head of leaves like a noble palm tree. Other trees more or less resembling palms, and others like existing firs, also abounded, giving a richness and variety to the scene; while one gigantic species, strikingly resembling the *Altingia*, or Norfolk Island pine, might be seen towering a hundred feet or more above the rest of the forest, and exhibiting tier after tier of branches richly clothed with its peculiar pointed and pear-like leaves, the branches gradually diminishing in size as they approach the apex of a lofty pyramid of vegetation.

Tree ferns also in abundance might there be recognised, occupying a prominent place in the physiognomy of vegetation, and dotted at intervals over the distant plains and valleys, the intermediate spaces being clothed with low vegetation of more humble plants of the same kind. These we may imagine exhibiting their rich crests of numerous fronds, each many feet in length, and produced in such quantity as to rival even the palm trees in beauty. Besides all these, other lofty trees of that day, whose stems and branches are now called Calamites, existed chiefly in the midst of swamps, and bore their singular branches and leaves aloft with strange and monotonous uniformity. All these trees, and many others that might be associated with them, were perhaps girt round with innumerable creepers and parasitic plants, climbing to the topmost branches of the most lofty amongst them, and enlivening by the bright and vivid colours of their flowers the dark and gloomy character of the great masses of vegetation.

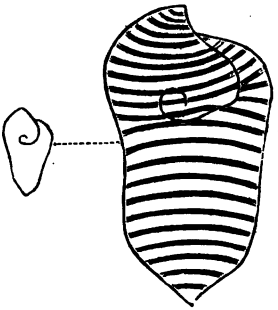
Forests like these (and I have in this description confined myself to a strict analogy, and have very cautiously abstained from transgressing the bounds of probability) are at the present day remarkable even in islands of large size, for their death-like silence, and for the almost total absence of living beings. A few birds and insects seem to form almost the whole population. In many cases no quadruped exists over extensive districts; and it is manifest that most of such islands have depended upon migrations for their inhabitants, so that they offer no guide whatever to the naturalist, when he wishes to determine from them the indigenous animals or vegetables of the district.

If, however, this is the case with the islands of the Polynesian archipelago, it cannot be doubted that the fragments of organic matter carried down into the mud and sand to form coal, and deposited in the creeks and at the mouths of rivers in ancient times, must be looked upon as offering still less evidence with respect to terrestrial animals; and what evidence exists on this subject is almost confined to about half a dozen isolated specimens of organic remains.

The conditions and contents of the newer formations of the secondary epoch, render it also probable that land animals, if existing at all, were yet more rare in the older period than afterwards, since, in the few localities where fresh-water fossils are found under similar circumstances in newer beds, (as in the oolites and wealden,) the remains of land reptiles, and even of mammals, have been discovered.

All that can be made out from the fresh-water limestones and other beds of the coal-measures is, that at this period a few insects were in existence, and were associated with some very minute crustaceans (the annexed diagram will give an idea of one of these) and several shell-fish. No fragment of a quadruped, bird, or reptile has, however, yet been obtained from any of the carboniferous strata in any part of the world, although there are not wanting in some of the sandstones associated with the coal of North America distinct indications of foot-prints referred to birds and perhaps reptiles.

Fig. 32



CYPRELLA.
The smaller figure is of the natural size.

The inhabitants of the sea during the carboniferous period are, as might be expected, much more clearly made out than those of the land; and their remains are in many cases very abundant, and sufficiently distinctive to enable us to determine the modifications and changes that had taken place since the deposition of the first fossiliferous bed.

And, first, with regard to the corals, we find indeed new species, but the differences are small and unimportant. The encrinites, so similar to the coral animal in some respects, had also been replaced by new species, the forms having become on the whole more complicated. Higher groups, too, of radiated animals were introduced, and the sea-urchin and the star-fish, although rare, were not unknown in the sea. Trilobites still remained, and herded together chiefly in shoal water near the muddy and sandy bottoms; and some other small crustaceous animals are known from imperfect fragments of them occasionally found fossil.

But the shells of molluscous animals are too abundant, too varied, and too widely distributed in the rocks of the carboniferous period, to be passed over without some careful notice. Those of Brachiopoda (e. g. *Spirifer*, *Productus*, and *Terebratula**) chiefly preponderate, although not so much so as in the older rocks, while the cephalopods, also very abundant, are developed in new forms, many of them being intermediate in their structure between the nautilus and the ammonite, and others retaining the simple form of the orthoceratite.

The Productus (fig. 34) is a very remarkable and interesting shell, although the exact nature of the animal inhabitant has not yet been satisfactorily made out. The shell is of a very fibrous texture, and a number of fine tubular or hair-like appendages are, in many cases, attached to it, sometimes passing through the fibrous shell, but at other times only extending from the line of junction of the two valves, which are not connected by any hinge, and which were probably at once united and fastened to some solid body by this contrivance. As in the other brachiopods, there appears here also to have been a mechanical contrivance for keeping the valves partly asunder; and it would seem, that, at least in some species, the shell was very thin, and readily adapted itself to the shape of the stone on which the animal had fastened itself. The fossil shells of the productus are extremely abundant throughout the carboniferous limestone, and are found in a limestone overlying the coal-measures; but they are rarely found in the millstone grit or the coal-measures themselves, the circumstances of the deposit being probably unfavourable for the existence of such animals.

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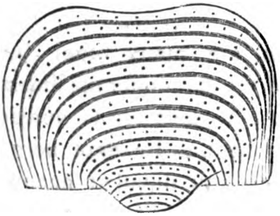
* *Spirifer*, Latin, *spire-bearing;* so called because a coil of carbonate of lime, useful probably in keeping the shell partly open, is not unfrequently seen in the shells of this genus. An analogous contrivance is met with in most members of the order of Brachiopoda in some shape or other.

Productus, prolonged, or drawn out in length; one valve of the shell being in most species prolonged beyond the other, and often to a great extent.

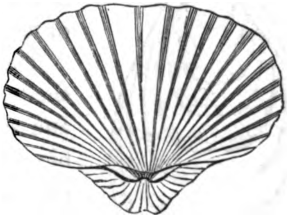
Terebratula, from *terebratus*, pierced; one valve being pierced at the apex, to admit of the passage of a fibrous bundle proceeding from the other valve, serving to attach the animal to some hard substance, as a stone or rock.

Fig. 33



SPIRIFER.

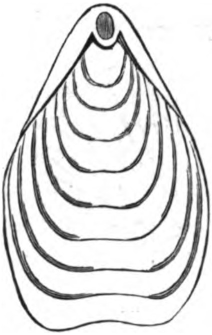
Fig. 34



PRODUCTUS.

The singular spire of the Spirifer (fig. 33,) often well preserved and generally occupying a considerable portion of the interior of the shell, is characteristic of the genus, and alluded to in its name. The shells of this group are not by any means strictly confined in locality or limited in its range, and, with the exception of the terebratula, they are perhaps the most widely distributed of the fossils of the first epoch. Several species pass likewise into the lower beds of the middle epoch; and it is not unlikely that some of the species referred to terebratula, and now living, may ultimately be recognised as spirifers. The species of terebratula of the mountain limestone (fig. 35) are not very strongly marked, and some of them are capable of misleading the young fossilist by their great resemblance to shells of a much newer period. The species figured admits of a singular extent of variety of form.

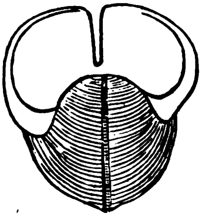
Fig. 35.



Terebratula hastata.

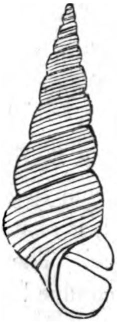
There are many other bivalve shells of the carboniferous limestone, and some of them are of considerable interest, but I cannot here venture upon any detailed account of them. On the whole, there is a manifest approach to the existing type, although many genera at that time existed, all the species of which have since vanished, and a much greater number of new genera have been since introduced.

Fig. 36



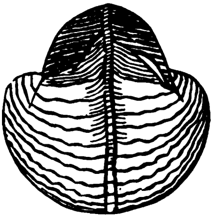
Bellerophon.

Fig. 38



Murchisonia.

Fig. 37



Bellerophon.

Of univalve shells there are several which seem to have been either chiefly or entirely confined to the rocks of the carboniferous period. The name *Bellerophon*[*] (fig. 36, 37) has been given to one genus of doubtful affinity, which has been referred in succession to various groups of Mollusca, and even to the Pteropoda, known to occur in the silurian rocks. The great thickness of the shell, its structure and mode of growth, and the kind of shells associated with it, render it more likely, perhaps, that the animal belonged to the Gasteropoda, and was not far removed from the limpit.*

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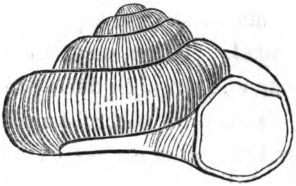
[*] *Bellerophon*, a Greek name of a person supposed to have lived in the heroic age. As applied to the fossil, this name is entirely fanciful.

Fig. 39

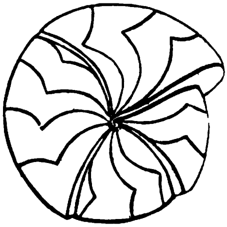


EUOMPHALUS.

The *Cirrus*,† a flat shell, composed of a number of whorls, and often attaining an enormous size, seems to have inhabited the same muddy bottoms near shore; and the *Euomphalus*‡ (fig. 39) probably resembled it in habit.

But the cephalopodous inhabitants of the seas during the carboniferous period were still the most important and the most numerous of the molluscous animals; and they included not only the straight shells of orthoceratites, but a large number of spirally twisted species, bearing a somewhat different relation to the nautilus. The most important are called *Goniatites*§ (fig. 40.) The nature of the difference here exhibited, and its influence on the habits of the animal, will be considered in a fu-

Fig. 40



GONIATITE.

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* De Koninck, Animaux Fossiles de la Belgique, p. 334.

† *Cirrus*, a curl; so called from the form of the shell.

‡ *Euomphalus*,—ευ (*eu*,) elegant; ομφαλος (*omphalus*,) a boss; so called from the well-marked and distinct proportions of the shell.

§ *Goniatites*, γομος (*gonos*,) an angle; from the angular markings made by the intersection of the walls of the chambers and the outer shell. (See cut.)

ture chapter, when speaking of the Ammonites, fossils of a yet newer period.

It has been already mentioned that the fishes, which, during the devonian period were for the most part of small size, and could not have been extremely formidable or powerful, were gradually advancing in development towards the latter part of the period, and that several new forms, of strange aspect and gigantic size, were then introduced. These seem to have attained their maximum of size and strength during the carboniferous epoch.

Two great natural families of fishes, one of them entirely, and the other almost extinct, seem to have occupied at this time the place of the great marine reptiles which succeeded and displaced them. These two families are nearly allied to each other, and present many remarkable and close analogies to the true saurians or reptiles, and for this reason the one first determined was named *Sauroid.** The sauroid or reptilian fishes, although met with throughout in the rocks of the secondary epoch, and often very abundant, no where attain so great a magnitude, or offer such perfect types of their development, as in the earlier seas, whose inhabitants we are now considering.

So intimate is the resemblance, and so nearly perfect the passage between fishes and reptiles through these sauroid fishes, that very little is wanting to complete our knowledge of the numerous extinct forms, in spite of the rarity of existing species with which to compare them.† It will, however, be better to confine our attention chiefly to the one or two genera most remarkable and most characteristic, in order to obtain an idea of the peculiarities which distinguished the ancient fishes from their living type.

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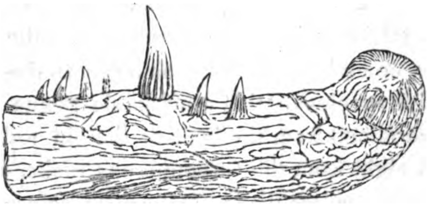
* Σαυρος (*sauros*,) a lizard; ειδων (*eidon*,) resembling: from the strong saurian or reptilian analogies exhibited, chiefly in the teeth.

† The existing sauroid fishes consist of seven species only, five of them belonging to the genus *Lepidosteus*, or bony pike, which are sufficiently common in the great American rivers; and two species of *Polypterus*, one from the Nile, and the other from the Niger. The scale of one species of Lepidosteus is figured in page 71, fig. 20.

The *Megalichthys** (fig. 41,) as its name imports, was an animal of large size, and seems also to have been of great strength. Its head was large, and the gape of the jaws enormous; the jaws themselves powerful, and provided with a range of most formidable teeth, of which some of enormous size projected far beyond the rest, as is the case with the crocodile. The dimensions to which the animal must have attained may be imagined, when it is known that these teeth have been found measuring four inches in length, and nearly two inches broad at the base, a size rarely if ever met with even in the largest reptiles. The body, covered with scales of corresponding magnitude (sometimes five inches in diameter,) was well shaped for swimming, being formed upon a robust bony skeleton, and provided with an extremely large and powerful tail, enabling it to advance with extreme rapidity. It must have been eminently carnivorous, and capable of pursuing and taking almost any living creature among its contemporaries.†

Fig. 41.



Jaw and Teeth of Gigantic Sauroid Fish.
(*Megalichthys.*)

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* Μεγαλη, (*megale,*) great; ιχθυς (*ichthys,*) a fish.

† Although unquestionably a fish of large size, and, compared with other fishes of the ganoid order, truly gigantic, it was by no means so with

The *Holoptychius*,* a genus nearly allied in many respects to the sauroids, seems to have differed from that family in some important points of structure. The specimen best known of this fish is about thirty inches long without the tail, and exhibits the most singular and robust proportions. Although the head is small, the naked jaws (covered with enamel instead of skin) are lined with a double row of formidable teeth, the outer ones being thickly set and fringing the enamelled edges of the mouth, but the inner ones wider apart, and at least twenty times the size of the others. The scales on the body of this fish, and the bones, are so like what is seen in reptiles, that they were, when first discovered, supposed to belong to some large saurian; and the scales might indeed have served for the defensive armour of a crocodile five times as large as the fish. Not less than five species of this remarkable genus have been already determined from the beds of the old red sandstone period, and eight from the carboniferous rocks, all of them exhibiting more or less distinctly the peculiarly massive and robust character of the family.

But the great reptilian fish were not the only inhabitants of the sea during this period, nor were they even the only ones of large size and possessed of great strength and voracity. Not less than sixty species belong to various genera, all nearly allied to the shark tribe and some of them of very large proportions, are indicated by the remains of teeth discovered in various localities in the limestones, sandstones, and shales of the carboniferous series; and thirty-three species have been determined from fragments of fins and detached vertebræ from the same beds. Now, as there are

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reference to many existing tribes. The ganoid fishes, however, were generally small or of moderate dimensions.

* Ολος (*holos*,) entire, complete; and πτυχη (*ptyche*,) a wrinkle, or fold: the fish's scales being entirely covered with wrinkled markings.

no more than seven species of shark-like animals determined from the fossils of the old red sandstone, even including two which may be indentical with some of the other five, it seems that a great and important change had taken place in the introduction of a large number of species of this class, which was very imperfectly represented at first, but which continued important for a very long time, and still forms a group performing a distinct part in the economy of creation.

Fragments of placoid fishes, whose remains, although consisting only of teeth and bony fins, are thus abundant in species, are in some places very common.* They were not, like those of the former class (the ganoids,) securely encased in enamelled armour, but were covered at intervals with small detached plates, which could scarcely serve the purpose of defence. It is probable that this was little needed, and that the animal depended chiefly on its extreme swiftness of motion both to óbtain its prey and escape from its enemies; while the perfect apparatus of teeth (the commonest fossil remains of these fishes) indicates beyond doubt its ordinary habits; and the bony rays (also very frequently met with) attest the provision that was made to enable the animal to turn itself on its back and seize its prey when overtaken, with a rapidity and precision of which we are scarcely able perhaps to form an idea.

The numerous rays, or bony spines, called *Icthyodorulites*,† so often found fossil in these and newer strata, seem to be identical with the bony spine with which the Port Jackson shark is provided, and which being moveable, and attached to a fin, enables the animal to turn itself readily on its back while swimming. These spines are variously marked according to the species or genus to which they belong. They will be described at greater length in a future chapter when treating of lias fossils.

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* Among the most remarkable localities are several in the carboniferous limestone of Bristol, and others in the same rock in the neighbourhood of Armagh.

† Ιχθυς (*ichthys*,) a fish; δορυ (*doru*,) a spear; λιθος (*lithos*,) a stone: these fossils being spear-like projections from the back and belly of a shark-like fish, supporting fins, and serving probably also as weapons.

See then the great and striking change that had supervened towards the close of this carboniferous period. The corals and the encrinites remained with little alteration of general form; the trilobites were nearly extinct, and seem but scantily replaced by other crustaceans; the Brachiopoda had assumed new forms, which some of them retained long afterwards, and which are even handed down to the present day;* the ordinary bivalve and univalve shells were gradually increasing; and the prevailing Cephalopoda, retaining up to this period the elongated straight form of orthoceratites, were also developed in the spiral form seen in goniatites, and afterwards continued in ammonites,—a form better fitted perhaps for the altered conditions of the sea and the greater stir of life that was about to succeed. But the fishes present the newest and the most striking appearances. The minute, but probably fierce and voracious species, which first marked the introduction of this class of animals, had been succeeded by a comparatively clumsy and awkward race, coarse feeders, of small size, and indifferent swimmers, but covered either with strong plaited armour or with fine coats of mail, and apparently very abundantly distributed. These lasted for a time, but then gave way to the advance of other and higher groups. Innumerable sharks of all sizes, and perhaps of many forms, rapid and powerful swimmers, fiercely and insatiably carnivorous, were associated with huge monstrous fishes, more resembling reptiles than any of their own class at the present day, and incredibly powerful and voracious. The fishes at this time had attained, it would seem, their maximum of development in point of vigour, and in some respects (though in some respects only, and by analogy) in structure; and it is not a little interesting to find, that, at this point, so far as we can tell, the true reptiles were actually introduced (the remains of that class being indicated in the coal-measures, and actually found in the magnesian limestone associated with carboniferous species of fishes.)

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* Some Terebratulæ of the carboniferous period are exceedingly like oolitic species, and some of them closely resemble species still existing.

The reptiles thus appearing were not, however, members of that group through which the passage from sauroid fishes to true saurians takes place, but belonged to a higher form and to a complicated type of that form. It seems clear, therefore, that, while progression and a general advance in point of organization is in one sense a method observed by nature, still there is not such a regular gradation that an animal of lower organization can be supposed to be employed as the agent in introducing a higher group; this view, however plausible, not being borne out by observation, but, on the other hand, being distinctly contradicted by the results of geological and palæontological investigation.

CHAPTER VI.

THE CLOSE OF THE FIRST EPOCH OF CREATION.—THE MAGNESIAN LIMESTONE, OR PERMIAN SYSTEM OF DEPOSITS.

After the coal-measures had been deposited in the creeks and at the mouths of rivers, and probably very near the land anciently existing, a great change seems to have taken place in the northern hemisphere in the relative level of the land and sea bottom, so that a quantity of coarse gravelly matter, apparently the debris of some sandy or granitic rock, was more or less abundantly deposited. This sand sometimes reposes conformably and evenly on the upper coal grits, which pass into it: at other times the upper surface of these latter beds has previously undergone much wearing and grinding away, and occasionally the lower beds, originally horizontal, have been tilted up at various angles to the horizon, and the upper ones removed before the newer sandstones were placed upon them.

Notwithstanding the turmoil and agitation which marks this movement in some districts, it is yet certain that the disturbances began by small and comparatively unimportant changes of elevation, occurring at intervals and at distant points, so that the general aspect of submarine life, as known by the fossils found embedded, was scarcely so far altered as to require the introduction of any distinct groups.

With regard to our own country, the principal deposits subsequent to the carboniferous rocks fringe these rocks both on the western and eastern sides. They pass in some cases by regular transition from the coal-measures, occasionally containing similar fossil vegetable and animal remains, and rarely indicating the lapse of any long period corresponding to a considerable break in the continuity of the successive strata.

Overlying the course sandy beds which rest upon the coal-measures, there is next met with a limestone, (the magnesian limestone,) which differs considerably from most of the ordinary limestones in its general appearance, and which, in the possession of a variable proportion of carbonate of magnesia, mixed with its carbonate of lime, seems to have required either a totally different condition of deposition from any with which we are acquainted, or a subsequent change only seen at present in recent volcanic districts, and then on a small scale. This limestone, however, contains fossils, and among them a few corals and shells; and there are also found in it fragments and sometimes complete skeletons of fishes, which seem to have been tolerably abundant in the seas, since whole beds are charged with animal bitumen, probably derived from their decomposition, and in these beds the skeletons and other indications of the fishes are more than usually plentiful. But the most remarkable phenomenon of the magnesian limestone and contemporaneous strata is the presence in them of distinct reptilian remains, at least five species of which have already been made out.

Over various parts of the continent of Europe, as in our own island, the coal-measures are more or less covered up with beds, consisting of this course grit overlaid by clay and limestone, the clay being often remarkably bituminous, and the limestone generally exhibiting the chemical peculiarity already alluded to, containing a certain proportion of carbonate of magnesia, mixed with the carbonate of lime. In the east of Europe, however, and more especially in Russia, this series is exhibited in its greatest completeness. It is there found occupying a hollow or trough-like depression in the carboniferous strata, and is said to extend for a distance of nearly seven hundred miles from north to south, and for four hundred miles between the Ural chain and the river Volga, in the ancient kingdom of Permia, now included within the vast compass of the Russian empire. In this tract conglomerates and grit-stones, with magnesian and other limestones, make up the series, and contain fossils identical with those common in Durham and the neighbourhood of Bristol. Over the whole of Europe, therefore, similar causes seems to have acted in producing this series of magnesian strata at the close of the carboniferous period; and a dreary waste of sandy unproductive beds seems to mark the disappearance of land clothed with vegetation, and the gradual deepening of the sea, which at first received rolled and pounded fragments of rock, carried out to a distance in the form of sand, until afterwards, the land diminishing and disappearing, even this small supply ceased, and scarcely any deposit or any fragment of organic existence was retained, in consequence of the absence of material in which it could be buried and preserved.

The nature of the remains of fishes found in the magnesian limestone rocks indicates also a diminution in the size of the prevailing species, perhaps arising from the gradual diminution and increasing distance of the land, and the deepening of the sea in the district where such remains occur.

The reptilian fishes remain indeed, but they also become small: those of the shark tribe are few, and exhibit some peculiarities of structure, but are comparatively unimportant; and the rest were chiefly the bad and slow swimmers, or bottom fish, living on offal and on the invertebrated groups.

But a time of much greater change was approaching—a time of disturbance, which should shake to their foundations all the solid and massive rocks that had been then deposited; and of subterranean movements, which in their course should break asunder the hardest and the strongest among these rocks; crushing and grinding into small fragments whole strata that had become compact and closely consolidated, and crumpling into complicated folds the toughest and most unyielding beds, as if they had been layers of some soft material carelessly squeezed in the grasp of a powerful hand.

It is indeed impossible for words to express the complication of disturbance, or the amount of confusion, that has been produced in some districts by forces acting on the solid crust of the globe, between the close of what we have called the first epoch, and the commencement of the second; and yet all this was done with a certain degree of order, and doubtless occupied a long period of time. Volcanic eruptions have taken place in some districts, and their effect is seen in torrents of ancient lava, heaps of erupted ashes, and rocks chemically changed by the intrusion of heated vapours charged with gases. In others, enormous cracks extending for many hundred yards, or even for miles together, may be traced in the more brittle rocks; and the rocks themselves have been burnt as in a furnace by the boiling and bubbling mass of molten lava which has been poured from beneath into such wide fissures. Sometimes extensive tracts, where the rocks are thinner and tougher, have exhibited these cracks in systems of hundreds in number parallel to one another; while here and there the intense fiery action from beneath has thrown up the surface into blisters and domes, which are often fractured at the top, and thus reveal the history of their elevation. Still more frequently, also, the irresistible subterranean force has snapped asunder the strata, as a violent blow would pierce through a few folds of paper, and one side of the broken bed has been lifted high in the air, or has sunk into a deep hollow beneath. And if, as happened occasionally, the force was not sufficiently energetic to break up in this way the whole group of over-lying matter, it might yet effect a no less striking result, raising up the strata upon a line or on a point, and producing a saddle-shaped or a dome-like elevation, according to the circumstances of the case.

All these effects, and all of them on the grandest scale, were produced in some way or other upon many of the old rocks towards the close of the first epoch of creation; and every Geologist, familiar with the structure of our own island, could readily point to abundant examples of each particular disturbance above alluded to. Every coal-field is so split asunder and broken into small fragments by what are called "faults," (cracks and consequent disturbances of the strata,) that they alone might be appealed to as sufficient proof; and, indeed, the very appearance of the smaller coal-fields of the middle of England, lifted as they are far above the great expanse of the new red sandstone, is due solely to these under-ground movements, which have borne to the surface portions of the carboniferous and lower strata, that would otherwise have been hidden.

It is not unlikely that much of the general contour of the high ground of England and many parts of northern Europe was originally marked out during the restless disturbances of this interval of violence. The districts occupied by the mountain limestone and the older rocks, at least, have probably in later times been disturbed only by movements affecting the general level of large tracts; and there cannot be a question as to the intensity and continuance of the forces acting beneath the surface at that time having been then much greater than any that have since affected that portion of the earth's crust exposed for investigation in our own island.

These remarks apply chiefly to the physical geography and geology of England, but they also describe with very little modification a large proportion of all those tracts in which the carboniferous and older rocks appear. Exceptions, it is true, are not wanting; and a very interesting one is met with in Russia, where various rocks of this first epoch stretch over a vast extent of country, and seem to have been little disturbed, except by exceedingly slow movements of elevation, since they were originally deposited. We shall find hereafter, that, on the one hand, similar elevatory movements and corresponding depressions were continued incessantly at intervals to a very recent period, (and, indeed, there is evidence that they have not yet ceased in our own latitudes in Europe,) while, on the other hand, very few instances are known of extensive dislocation affecting the beds newer than the magnesian limestone in the British islands, at any period except that one marked by the commencement of the tertiary series of deposits.

There are no means whatever by which we can at present determine how long a time elapsed between the conclusion of the first great series of deposits in England and the commencement of the next; nor is it for us to assert that the wild and chaotic confusion resulting in all those violent dislocations of the hardest strata, which we so readily observe, was in any way inconsistent with the existence of life in many other parts of the world, now, perhaps, covered hundreds of fathoms of salt water. But I would not dwell on this possibility, for I wish only to speak of what is known; nor can it be necessary to wander into the field of conjecture and romance, in order to obtain a striking picture of a former state of existence which shall exhibit all the charm of novelty, both in the outline and colouring. Without any such conjectures, of one thing at least we are certain: that during this interval, whatever it may have been, and however it may have been occupied in various parts of the world, every species of animal, and almost every vegetable, seems to have been replaced by some new one, not differing much perhaps from the former, or performing another office, but yet different,—exhibiting an instance of the rich variety of nature, and an effect of that law of universal dissolution which appears to influence species, as well as individuals, allotting to each its appointed time, and causing each to pass through the different phases of imperfect development, full growth and vigour, and then gradual but certain decay and death.

Little as the transition from the rocks of the older to those of the secondary period is marked by mineral changes in the strata, this total difference in the nature of the organic remains is far too important to be passed by without notice. Both the upper part of the magnesian limestone series, and the strata that are superimposed, consist of sands often loosely aggregated, but sometimes hardened into stone by the infiltration of oxide of iron or some other cementing medium. Neither of these beds is prolific in fossils, but each contains a few; and this is the case as well in England as on the Continent, where the development is much more remarkable, and where the beds contain many more fossils. The difference between the organic remains of the two beds is, however, total, and in fishes is carried even into a point of structure which seems to be connected, though in an obscure way, with the whole organization of the class.* The vegetation, too, of the newer period is distinct; and the introduction of reptilian animals in great abundance, and of large size, offers a characteristic of considerable interest.

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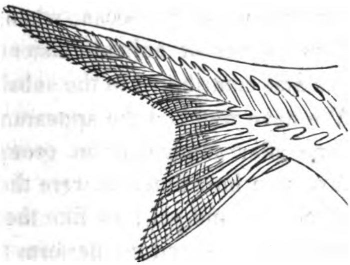
* In the fishes met with in the older rocks the vertebral column is invariably continued to the extremity of the tail (fig. 42;) and the upper lobe of the tail-fin, into which the back-bone extends, is larger than the other. In the rocks of the secondary period, the vertebral column does not extend into the tail, but the tail-fin is generally unsymmetrical, the upper lobe being the largest. In more modern fishes the tail-fin is perfectly symmetrical in every respect (fig. 43.)

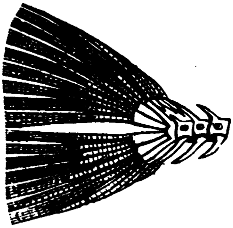
I have been the more anxious to mark the existence of this break in the general continuity of the various strata, because, unlike that occurring after the deposit of the chalk, it is by no means distinctly visible to every one, nor is it altogether understood even by many Geologists. It is, however, almost equally important with respect to the great standard of comparison, that of organic life, and its conditions have been worked out carefully, although they have only lately been so satisfactorily proved as to admit of confident and direct assertion. One reason of this may perhaps be, that of the disturbances ultimately so effective we see in some cases the first small commencement, and are enabled to trace the gradual change in the general character of the deposits, and perceive the mineral structure of the beds insensibly adapted to the new state of things. Another reason undoubtedly is, that the changes produced on the older rocks after the deposit of the carboniferous system, are very

Fig. 42.



HETEROCERCAL TAIL.
(*Platysmus.*)

Fig. 43.



HOMOCERCAL TAIL.
(*Pristipoma.*)

much hidden and covered up, in consequence of their long exposure to aqueous action, and perhaps also to the atmosphere, during the countless ages that have elapsed since the commencement of the secondary epoch of creation.

We pass on now from the consideration of this chapter in the world's history. We have seen, first of all, how the earth lay buried in the dark obscurity of its early state, when the only rocks of mechanical origin consisted of huge masses of decomposed and pounded granite, broken into fragments by the disruption of the first thin shell of solid matter; and in these deposits no evidence has yet been obtained of any created thing having existed, either animal or vegetable. We have traced the history from this time through the period when a few worms crawled on the mud and sand of the newly-made shores of the ocean, when to these were added other lower forms of animal existence, and when marine vegetables first contributed to the subsistence of its inhabitants. We have watched the appearance of its denizens, as they, one after another, or in groups, present themselves, and have seen how different were these from the present tenants of the sea, and yet how like them, and how evidently and admirably adapted to perform the part assigned them; and we have thus gazed upon the first doubtful and misty appearance of light and life, as they have become visible in the morning of creation by slow degrees, and through a long twilight. Trilobites, brachiopods, shell-fish of various kinds, are seen to abound; and the cuttle-fish, or creatures nearly allied and not so highly organized, reign for a time undisputed lord of the sea. At length their reign terminated; other animals, of higher and more complicated functions, succeeded, and the waters, after a long preparation, became fit for the presence of fishes. These, at first of small size and comparatively powerless, soon increased rapidly both in number and dimensions, and, encased in their impenetrable armour, seem to have delighted in the troubled ocean where the coarse conglomerate of the old red sandstone was being accumulated; and for a long while these less perfect species of the class were predominant. In time, however, other fishes sprung up, the old ones were displaced, and a new, vigorous, and powerful group of animals came into the field, endowed with exuberant life, and darting with speed and with almost irresistible force through the water. Land, also, richly clothed with vegetation, even to the water's edge, contributed to support this abundant flow of life; and some few land animals of high organization appear to have been associated with the insects and the fresh-water animals whose remains have been preserved. But few, indeed, were the tenants of the land, so far as we can judge, when compared with those of the ocean; and while we have in so many parts of the world a rich supply of the vegetable remains of that period, there are only to be quoted the fragments of a scorpion, one or two foot-marks, and such like indications that nature was not inactive, though the conditions for preserving any terrestrial animal remains were so eminently unfavourable, that there is only just sufficient evidence to satisfy us of the fact.

The conditions of aqueous deposit were, however, more advantageous so far as marine animals were concerned; and during this period, and especially towards its close, we find that the fishes assumed their maximum of development, at least in the placoid and ganoid orders, for at this time the reptilian fishes and sharks were both numerous and powerful, while very soon afterwards the whole tribe of fishes was represented by animals of smaller dimensions, of different habit and comparatively powerless. It is very interesting in this case to watch the progress of the transition. The fishes in the carboniferous rocks, include many large shark-like and reptilian groups. In the sandstone above the coal, and in the magnesian limestone, are many nearly allied fishes, although of much smaller size, but all the more advanced types seem to fail. In the same newer beds, however, appear true reptiles, not indeed of large size, but of complicated dentition, and the representatives of a high group; while as we shall hereafter find, in the beds of the secondary period the reptiles at first exhibit high analogies and then pass off into a magnificent series, including true representatives both of the earlier sauroid fishes and the later aquatic mammals. On the other hand, the fishes there exhibit a lower form of higher groups, afterwards continued and advanced to the most complicated types, but only attaining a gigantic size in rocks of far newer date. The bearing of these points on the general question of development we shall have occasion afterwards to allude to.

THE SECOND OR MIDDLE EPOCH.

CHAPTER VII.

THE COMMENCEMENT OF THE SECOND EPOCH:—THE FORMATION OF THE NEW RED-SANDSTONE, OR TRIASSIC SERIES.

OVER a large part of the known world, the close of the first epoch, marked by great subsidences of land, by the swallowing up of continents and islands into the sea, and by accompanying violent dislocations of the stratified crust of the globe, was of necessity accompanied by the re-distribution of these fractured materials of strata; and, owing no doubt to the great amount of trituration, the beds thus formed contain but few remains of organic beings. These, however, indicate the commencement of the new era.

The presence of the new red sandstone, a formation consisting of sand and marl with rare local interpolations of limestone, characterizes this epoch; and, after this, until towards the close of the secondary or middle period, we find few intermediate beds over the whole of America;* and the same is the case with regard to the greater part of Asia and Australia, as far as Geologists have yet been able to determine.

In England we have this chapter of the history much more fully developed. The new red sandstone itself, it is true, consists of little more than loose sand and mud, deposited, perhaps, rapidly, from the fractured rocks of the earlier period. It is, therefore, very poor in fossils, and exhibits but few of these hieroglyphics whose language we can interpret; and, although richer in this respect than England, the whole continent of Europe is marked by a similar comparative rarity of organic remains in the beds. But afterwards, it would appear that, the subsidence not having been complete, there remained in our latitudes a number of islands, forming an archipelago not unfavourable to the existence of many races of animals and vegetables, especially those capable of supporting life in spite of constant oscillations and changes of condition of the surface.

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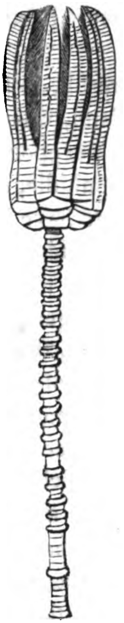
* There is, indeed, one magnificent exception in the Richmond oolitic coal-field of Virginia, U. S., where the beds of coal are of vast extent, and rival those of the true carboniferous period.

We have seen that, even up to the very close of the earlier epoch, there is no distinct and unquestionable evidence of the nature and position of the land on which grew the vast forests from which coal was elaborated. Here and there it has seemed that the trees of which we find fragments must have grown on the spot where broken trunks are now apparently attached to their roots, the roots and trunks being buried together in the very soil from which they obtained their nourishment. But these instances are rare and exceptional; and although we may be certain that the land was not far off, yet its exact position, and whether it was a continent or an island, or a group of islands, whether it extended southwards or northwards, whether it occupied what is now the Atlantic Ocean, or was shaped like Europe, and represented the two north-eastern continents, we cannot satisfactorily determine. Perhaps the most probable opinion is, that an extensive archipelago, like that near the eastern shores of Asia, was the remnant of a sinking tract throughout a great part of the north temperate zone; that portion of that tract, now forming parts of England and central Europe, remained thus for a long time in shallow water, the recipients of many deposits; but that during this time the other tracts were too deeply submerged and too far from land to receive such additions.

Whatever the cause may have been, the result, so far as concerned the inhabitants both of sea and land, was sufficiently remarkable. Between the close of the older epoch and the commencement of this, which we call the middle, every species, both of animal and vegetable, seems to have been, almost without exception, changed. All the older forms have disappeared; all the modifications up to that time introduced have vanished; many even of the larger groups are so greatly altered, and have become so rare, that they also have nearly died out, either from the lapse of time or change of condition; and we have thus a new creation,—a new world, as it seems, supplying the gap produced by the mighty change, whatever it may have been, which closed one epoch of the earth's history and commenced a second.

But next in importance to the fact that this change has taken place to so great an extent, is a fact no less certain, that some species of one of the principal groups of the higher animals—the reptiles—were unquestionably introduced before the change took place; and this dawn of reptilian existence, observable in the magnesian limestone, gradually opens out into the broadest and fullest development of these singular animals, without exhibiting any marks of interruption, and as if there had been little or no disturbing action. Thus we have a link connecting the chain of beings, and uniting two conditions so dissimilar that whole families of fishes and invertebrated animals were unable to endure them; and this link moreover is one of great importance, and, as it might have seemed to us, the one least likely to be selected for this purpose. It may ultimately be found to have reference to the permanent elevation above the water of some portion of the land, while the sea bottom was undergoing great change of level.

Fig. 44.

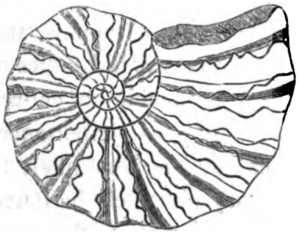


Stone Lily.
(*Encrinites moniliformis.*)

The seas of the new red sandstone period were not favourable to the development of the coral animal, but numerous radiated animals existed, of which the most interesting is that known to fossil-collectors by the name of the lily encrinite (fig. 44.)

This animal was one of a singular group already described (see p. 47,) enclosed within a stony habitation, and planted upon a stony but moveable column nearly cylindrical, and attached at its base to the solid rock. From the pouch, which is divided into five parts, as many pairs of smaller columns proceed, and each of these ten columns immediately splits itself into two, so that there are twenty moveable arms of no great length immediately above the body, each of them being provided with a number of fingers made up of similar small stony columns admitting of considerable motion, by means of which food could be obtained and conveyed at once to the stomach of the animal. It is calculated that nearly thirty thousand separate pieces of stone exist in the skeleton of this singular creature.

Fig. 45.



Ceratite.

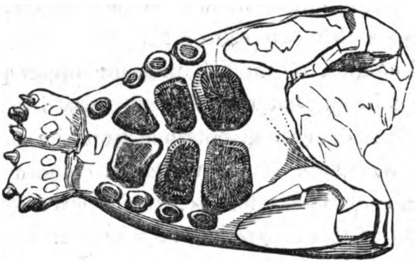
Among the shell-fish of this period, which is a kind of transition from the earliest to the next succeeding one, there are few species that require very special notice, although the whole group taken together is interesting, as showing an approximation in the general character to that of existing seas, without any of the species being identical, and with little approach even to existing genera. Among the cuttle-fish, and especially those animals of the group defended by shelly coverings, and resembling the nautilus, there is a curious example forming a link between the goniatite of the mountain limestone, and the ammonite of the secondary period. This shell is known as the *Ceratite* (fig. 45,) and will be alluded to again in describing the shells of the next group of deposits.

The fishes of the period we are now considering, while they differ from those of earlier date in one point already alluded to, are not unlike them in some respects. The difference consists in the non-prolongation of the back-bone or vertebral column of the fish into the upper part of the tail-fin, a condition that obtains with regard to all known species, without exception, obtained from the older rocks; while the termination of the vertebral column before the tail-fin commences characterises those of newer date. With the exception of this difference, of which it is not easy to conjecture the exact meaning, there was considerable analogy and much general resemblance of structure.

We may consider the fishes of these rocks as forming three principal groups. First, those with powerful crushing teeth in the palate, comprising animals which were probably for the most part slow swimmers, and feeders on the encrinites, crustaceans, and shell-fish, in the shoals and near shore;—secondly, those with sharp teeth, of small size, encased like the former in boxes of bone coated with enamel,—the representatives in fact of the sauroid fish, which played so important a part in the more ancient seas;—and, thirdly, the great and voracious tribe of sharks, coated merely with tough skin, dotted over with points of enamel, and swimming rapidly and freely in the open seas in search of prey.

There is nothing of importance in the earlier forms of the two latter groups, and they will be more properly considered when we come to the description of the inhabitants of the sea during the deposite of the newer rocks. Of the peculiar apparatus provided for the former, the annexed wood-cut (46) will give some idea. It represents the upper jaw of one species, with nipping teeth in front, small grinding teeth on the sides, and large crushing teeth in the palate. The form of this fish is not known.

Fig. 46.



Placodus. *
(Lower Jaw and Teeth.)

It would certainly be premature, in the existing state of our knowledge of fossils, to assume the absence or even the great rarity of reptiles during the earliest epoch of the earth's history, merely because we have hitherto only found in the last formed rocks of that epoch a few traces of reptilian existence. These indeed are sufficient to indicate the presence of a highly organized group of such animals, although they are too few and imperfect to give us much idea of their habits, their relative importance, or the extent of their distribution. But, judging from analogy and from the extreme prevalence of a group of fishes organized like reptiles, and performing the part afterwards taken by several species of this latter class, it is hardly too much to assume, that the time of greatest development of the reptilian fishes preceded that in which the true reptiles themselves abounded. At any rate, it is quite certain that while the remains of reptiles are so rare in the older rocks, only a very few instances of them having as yet been met with, we no sooner enter on the examination of the new red sandstone, than we find indications of the existence of several remarkable forms. These soon increase so rapidly, that by far the most striking and characteristic organic remains of the next succeeding period are reptilian, proving that such animals were then at least, if they had not been before, among the most important of the inhabitants of the sea.

It is not an unusual thing, in examining sandstone rocks, to find indications not only of an ancient sea bottom, but also of that intermediate space between the reach of the highest tides and low water which formed the actual seashore, and was exposed alternately to be trodden on and indented by various animals moving over the damp sand, and to the influence of the waves of the sea. Among the more common indications of this state are the ripple-marks often seen on sandstone, and many irregularities of surface, apparently produced by the passage of worms, crabs, starfishes, &c.

Of all the ancient lines of sea-coast that have yet been introduced to our notice, there is none more interesting than that of the new red sandstone sea, for we find there not only marks of worms and the ripple of the water, but almost every other marking that can be imagined likely to have been made under such circumstances; and among these are distinct traces of the passage of numerous four-footed animals of many different kinds. Every one will remember the astonishment which Robinson Crusoe is represented to have felt at the sight of a human foot-print on the island which he thought deserted; and scarcely less surprising or interesting was the first discovery of these indications of animal existence in a rock so barren of fossils as the new red sandstone, and in a formation in which, till then, there had been no suspicion of the existence of any animals more highly organized than fishes.

Nothing, however, can be more certain, than that such foot-prints do occur; and although very little is to be determined from the mere form of the extremity, still even that little is of the greatest possible interest, when, as in the case before us, it is nearly the whole extent of our information. It is especially interesting to find that the foot-marks exhibit indications of some animals entirely different from those whose actual remains occur in the bed, and of some which present only faint and distant analogies with modern species, but which are yet made out by studying the peculiarities indicated in the rarest and most interesting of the fossils.

Of all the reptiles at present found on the earth, the frogs, both in their young state as tadpoles, and in many peculiarities of structure, seem to form the nearest connecting link with the fishes; and since there are few distinct analogies between recent species of reptiles and either birds or quadrupeds, the whole order Reptilia now forms an imperfect and isolated group, better adapted, it has been suggested, for a planet in an earlier stage of its existence, than for one peopled as our earth is at present.

The secondary, or middle period of the earth's history, however, as made known to us by the study of fossils, may be looked upon as the age during which reptiles preponderated, and we shall find, amongst the organic remains of this period, a great number of forms tending to give considerable insight into the plan of creation, with reference to this important department of zoology.

Among the links thus supplied, the fossils of the new red sandstone exhibit two animals, each offering some curious anomalies of structure, each somewhat highly organized, and while in many remarkable points of structure resembling one another, each presenting at the same time certain characters which connect the great class of reptiles, on one hand with birds, by a very unexpected route, and on the other with quadrupeds in a manner no less singular.

Both these animals seem to belong to the lizard tribe of reptiles, and one of them, the remains of which have been found in England, is called *Rhynchosaurus*,* while the other, obtained from the Cape of Good Hope, has received the name of *Dicynodon*.†

The *Rhynchosaurus* is known by the skull and several bones of the extremities, all of which were found some years ago in the Grinsill quarries, near Warwick. Impressions of the foot-prints of a small animal, probably an individual of the same species, were also found on some slabs of sandstone in the same quarry.

The skull of the Rhynchosaur differs essentially from that of any other known lizard, recent or extinct, resembling rather the beak of a bird, or that of the hawk's-bill turtle, than the head of a lizard, and this resemblance is increased by the absence of teeth. The bones of the jaw (see fig. 47) converge towards the front of the mouth, and form there a curved bony mandible, probably encased by a horny sheath.

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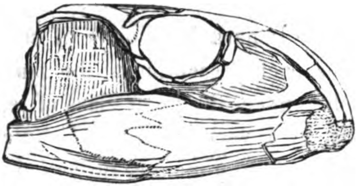
* Ρυγχος (*rhynchos*,) a beak; σαυρος (*sauros*,) a lizard.

† Δις (*dis*,) twice; κυνοδους (*cynodous*,) canine teeth, (having two canine teeth.) I have ventured to assume that the beds in which the Dicynodon remains are found are of the triassic period. The evidence of superposition, as far as it goes, seems to support the probability of this view, and is certainly in no point opposed to it, while the peculiarities of structure of these remarkable reptilian remains have suggested such a position as the most probable one. (See Geol. Trans., 2d ser., vol. vii. p. 53.)

Fig. 47.

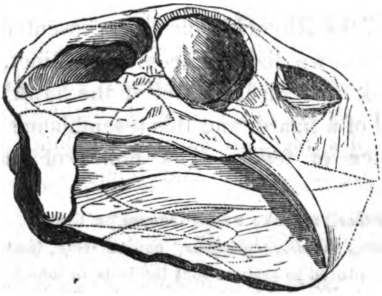


RHYNCHOSAURUS.
(Side View of the Skull.)

The bones of the extremities, found with this skull, indicate the terrestrial habits of the animal, and exhibit resemblances to the land reptiles of a later period, while the vertebræ present some interesting deviations from the lizard type.

The *Dicynodon*, with the same type of skull as the Rhynchosaur, and in other respects more nearly resembling this reptile than any other known animal, exhibits, however,

Fig. 48.



DICYNODON.
(Side View of the Skull.)

very singular modifications, pointing in one direction towards the poisonous serpents, in another to the carnivorous quadrupeds, in a third to the tortoises and turtles, and in a fourth to the crocodiles and lizards. The lower jaw exhibits no trace of teeth, but presents a smooth and even edge. The upper jaw is short, strong, and truncated, having at the back part two deep conical sockets, whence projected a pair of long and powerful, slightly curved and sharp-pointed tusks, directed downwards and slightly inwards. There is no mark whatever of any other kind of teeth, but it is probable that the animal used these tusks both as offensive and defensive weapons, and that its habits were carnivorous. The bones of the trunk and extremities have not yet been examined, but, from the structure of the vertebræ it is probable that the Dicynodon was at least partly aquatic.

Besides the foot-prints of small animals, probably like those little Lacertians already described, and many others which bear strong resemblance to those of tortoises and turtles, there are yet other impressions in many parts of the new red sandstone, some of them of very singular appearance. Among these are two groups, one apparently of birds, often of gigantic proportions, and the other exhibiting a foot-print like an expanded hand, also very large in some cases, and belonging to an animal of which it was for a long time impossible even to guess the true nature. The marks of birds have been found chiefly in America,* but are abundant and very strongly marked; so that, although no other indications whatever of these animals have yet been brought to light, it is impossible not to admit that they must then have existed.

The large five-toed foot-marks impressed on several beds of marly sandstone in various parts of England and Europe, more especially in Cheshire, in the tongue of land between the Mersey and the Dee, and at Hildburhausen in Saxony, bear so singular a resemblance to the human hand, that the unknown animal, to whose march over the ancient sea-shore they are owing, was long designated as the *Chirotherium.*[*] The dimensions of these marks are various,[†] but the prints of the hind feet are always much larger than those of the fore feet, in some cases four times as large, while the distance between the impressions of the fore and hind foot is often not more than an inch or two, even in the larger specimens, thus indicating a very great inequality in the length as well as magnitude of the two extremities. Beyond the facts thus made known by the form and proportions, and the relative as well as actual size of the foot-prints, there was no evidence whatever for a long time concerning the animal that had produced them.

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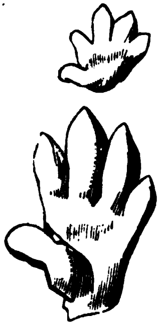
* It is only very recently that markings of the same kind have been observed, by Mr. Cunningham, on the surface of slabs in the new red sandstone quarries of Storton, near Liverpool.

Fig. 49.



FOOTMARKS.
(*Chirotherium.*)

At length, however, teeth and other bones were also discovered in the quarries of new red sandstone, and these were referred by their first discoverer to supposed crocodilian animals of considerable size. The more careful examination of these and other fossils by Professor Owen has greatly tended to throw light on the singular footsteps of the so-called *Chirotherium*, since they prove the existence of a reptilian genus, several species of which have been already determined, and which would seem to have possessed extremities capable of impressing those foot-marks, and certainly inhabiting the sea-shore in the place and at the time of their formation : this animal is now called *Labyrinthodon.**

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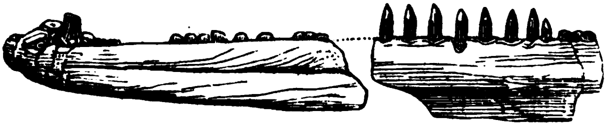
[*] Χειρ (*cheir*,) hand; *θηριον* (*therion*), a wild beast.

[†] In some of the specimens most remarkable for size, the length of the larger impression is upwards of twelve inches, the smaller one being about four inches long.

The result of the investigations terminating in the establishment of this genus seems to be, that the animals referred to it were intimately related to the salamander and the frog, belonging to the same order of Batrachian reptiles. But they exhibited peculiarities of structure connecting this tribe with the crocodiles, although the modifications of the jaws and palate, the arrangement of the teeth, and the disproportionate size of the hinder extremities, point to the frog as the nearest analogue by many striking anatomical peculiarities.

The Labyrinthodon must indeed be placed at the head of the Batrachian order; for, in dimensions and in general organization, it was far the most important animal of the whole group. The upper surface of the skull was broad, and flattened like that of the alligator, and its outer surface was deeply sculptured. The jaws were powerful, and armed with sharp teeth, the number of which was very great (probably upwards of a hundred on each side of each jaw. The

Fig. 50.



LABYRINTHODON.
(Left side of Lower Jaw with Teeth.)

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* *Λαβυρινθος* (*labyrinthus*,) a labyrinth ; *οδους* (*odous*), a tooth : so called from the complex or labyrinthine structure of a section of the tooth, as seen under the microscope.

teeth diminished in size towards both ends, but especially towards the muzzle, where, however, there were also much larger teeth, like tusks, reminding one in this arrangement of what is seen in the crocodiles.

The skin in at least one species seems to have been covered with bony plates. The mode of respiration, and hence, probably, the shape and use of the ribs, offered a still further approximation to the higher reptiles; but still, in many essential points, the Batrachian character is clearly to be traced, while the shape and general structure of the vertebræ points rather to the lower organization of fishes.

But the extremities offer the most interesting subject for consideration. They are partly crocodilian, and partly Batrachian. Some idea may be formed, both of their dimensions and of the general dimensions of the body, from the fact, that one fragment of a lower jaw, between nine and ten inches in length, corresponds to the same part in a crocodile six or seven feet long; while fragments of bones of the hinder extremity, probably belonging to an animal of the same species, if not to the same individual, are as large as those of a crocodile thirty feet long. If these bones really belonged to the same individual, the hinder extremities, however disproportionate according to the type of crocodilian structure, would not be excessive if they belonged to an animal having frog-like proportions. The actual size and shape, and the general appearance of the animal, are, however, still doubtful.

The evidence with regard to the animal of the footsteps (the Chirotherium) stands thus. We find in the new red sandstone certain foot-prints indicating a creature remarkable for the disproportionate magnitude of its hinder extremities, and also for the very singular shape of the foot. In beds of the same age, and in the same quarries, almost the only fossil bones found are those of a Batrachian or frog-like reptile (Labyrinthodon,) whose dimensions and proportions were sufficient, it would seem, to allow of its making foot-marks corresponding with these in the most essential character. It can hardly be considered unreasonable to conclude that the Chirotherium and the Labyrinthodon are one and the same animal.

The reptiles of the new red sandstones, besides those already enumerated, comprise another crocodilian genus; and if we may judge from foot-prints, they also include several turtles of various dimensions. These were probably the inhabitants of islands in a sea in which considerable deposits of mud and sand were constantly forming, and rapidly accumulating over the edges of the dislocated strata of older date. Perhaps, too, at this time there were occasional but considerable outbursts of volcanic matter from beneath the sea, helping to elaborate those remarkable beds of gypsum and rock-salt abundant in our own country in the beds of this age. During the whole of the deposits there would appear to have existed a tract of land to the east of England, chiefly between France and Germany; and this must have been somewhat extensive. From it were obtained many fragments of trees and plants, although rarely in sufficient abundance to form even thin seams of coal. The plants were unlike those of the carboniferous period, and they belong chiefly to the tribe of which the *Zamia* is now an important and characteristic type.

We may then imagine a wide, low, sandy tract by the sea-side, the hills and cliffs of limestone which still rise boldly on the shores of the Avon, and in Derbyshire and Yorkshire, having then been recently elevated and forming a fringe to the coast line. In some places, as in parts of Cheshire, between the Dee and the Mersey, in some parts of Warwickshire, and elsewhere where foot-prints have been left, slight oscillations of level were probably going on, and the line of coast was occasionally shifting. The sandy flats thus laid bare, and not reached by the ordinary level of high water, were of course traversed by the ancient animals of that period; but only a few faint records of them have been handed down for our observation, owing to the unfavourable nature of the sandstone for preserving organic remains. Amongst these, however, we are able to enumerate turtles and tortoises, a little lizard having a bird-like beak and probably bird's feet, birds themselves, some larger than an ostrich, others as small as our smaller waders; and in some parts of the world large reptiles with powerful tusks, not surpassed in the extent of their departure from the ordinary structure of reptiles by any known aberrant forms of that strange and varied tribe.

Amongst the most striking of these objects, at least on our own shores, would be the numerous and gigantic labyrinthodons. We may imagine one of these animals, as large as a rhinoceros, pacing leisurely over the sands leaving deep imprints of its heavy elephantine hind foot, strangely contrasting with the diminutive step of its short fore extremities. Another, a smaller variety, provided like the kangaroo, not only with powerful hind legs but also with a strong tail, also leaves its impress stamped upon the sand, although itself, perhaps, soon fell a victim to the voracity of its larger congener.* These and others of their kind, passing over the sands and marking there the form of their expanded feet, marched onwards in their course, fulfilled their part in nature, and then disappeared for ever from the earth, leaving, it would seem, in some cases, no fragment of bone, and no other indication of their shape or size than this obscure intimation of their existence.

It is strange that in a thin bed of fine clay, occurring between two masses of sandstone, we should thus have convincing but unexpected evidence preserved concerning some of the earth's inhabitants at this early period. The ripple mark, the worm track, the scratching of a small crab on the sand, and even the impression of the rain drop, so distinct as to indicate the direction of the wind at the time of the shower, these, and the foot-prints of the bird and the reptile, are all stereotyped, and offer an evidence which no argument can gainsay, no prejudice resist, concerning the natural history of a very ancient period of the earth's history. But the waves that made that ripple mark have long ceased to wash those shores,—for ages has the surface then exposed been concealed under great thicknesses of strata, —the worm and the crab have left no solid fragment to speak to their form or structure,—the bird has left no bone that has yet been discovered,—the fragments of the reptile are small, imperfect, and extremely rare. Still enough is known to determine the fact, and that fact is the more interesting and valuable from the very circumstances under which it is presented.

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* In some cases we find, corresponding to a set of foot-marks a continuous furrow, presumed to be the impression of a tail dragged along the sand by the animal while walking.

The result of an examination of the actual fossils of the new red sandstone of England offers little that is positive or definite, but when combined with these imprints found on the ancient shores, and with the fossils of beds of the same age on the Continent, it becomes more satisfactory. We may with great reason assume the existence of land, and can even partly trace its ancient boundary not far from the western coast of our island; but in what direction it extended, how far it reached, what was its nature, whether it was a continent or an island, or a succession of islands, and such like queries, are not at present capable of being answered. Neither do we learn much more definitely the general character of the animals and vegetables that were indigenous. A few fragments of fossil wood found in England are evidence of the fact that the land was partly clothed with large pine-like trees; and a few casts of shells show that its shores were peopled with some species of mollusca. Elsewhere, when the conditions have been more favourable for the deposition and preservation of organic remains, as in some districts on the Continent, we find still a comparative poverty. Plants, indeed, abound, and exhibit characters unlike those of the coal period; a bed of limestone (the Muschelkalk) contains numerous shells, and the remains of fishes and reptiles; but, on the whole, the general features remain obscure. It would almost seem that at this time, and in most districts which we can examine, there had been a destruction of the previous species, and that a sufficient time had not yet elapsed for the newly-introduced groups to spread over the earth and seas. However this may be, we cannot doubt the fact that there had been great and sudden changes, whether these were or were not connected with an interruption of the order of succession, and with the termination of one geological period, and the commencement of a second. The new red sandstone affords material for a distinct chapter in the earth's history, and though it is certainly a chapter containing less detail and fewer points for minute description than many others, it does not fail to suggest important generalizations.

CHAPTER VIII.

THE MARINE REPTILES, AND OTHER ANIMALS CHARACTERISTIC OF THE LIAS.

The deposit of sand and marly beds, which must have been steadily continued for a long time over extensive tracts at the commencement of the secondary period, seems to have gradually changed to a finer, more calcareous, and less sandy mud thrown down from suspension in water, perhaps after it had been carried for some distance by marine currents. This deposit of mud was local, since, so far as we can tell by examining the tracts now above water, it was almost confined to a part of England and a narrow tract in the middle of Europe, though it has been thought traceable in the middle of Asia, and is possibly represented in a small part of South America. The bed is sometimes more or less sandy or calcareous; but we know of few contemporaneous deposits; and where the muddy beds do not appear, there is often nothing intermediate between the new red sandstone and the newest beds of the middle epoch.

The most distinct beds of passage between the new red sandstone and this next superior stratum, (which is called *lias*,) are certain deposits at Aust Cliff, at the mouth of the Severn, where there is a thin bed absolutely made up of organic remains. There are also others on the continent of Europe, in the south of Belgium, near Luxemburg. In these cases the first and most important indications of change are seen in the increased proportion of argillaceous matter, accompanied often by carbonate of lime. The character of a calcareous clay, sometimes passing into a muddy limestone, may be traced in most of the varieties of this formation.

The lias* is every where singularly rich in the remains of organic existence; these remains extending through almost all the tribes of marine animals; and including, though rarely, fragments of wood and other vegetable bodies. No conclusion, indeed, can be drawn as to the nearness or distance of the land whence these fragments floated, for they are often covered with marine animals; but since, as will be seen, it is not unlikely that many of the monsters of the deep at this time repaired to the shallows, or even to the shore, to deposit their eggs, we may, perhaps, be allowed to conjecture that the land was not far distant from the spots now occupied by these strata.

The muddy liassic beds deposited after the sandstones described in the previous chapter, although they contained a considerable proportion of carbonate of lime, were not in a condition favourable for the development of coralline existence, and the remains of such animals are accordingly rare. This is not the case, however, with the closely allied group of Zoophytes known as the *Crinoidea;* for they, on the other hand, were singularly abundant, and were manifestly an important group, perhaps assisting to clear the seas of an undue proportion of the minuter particles of decaying animal matter. The most singular of all these is the *Pentacrinite*, an animal so complicated that the number of separate pieces of stone of which its singular skeleton is made up has been calculated to amount to not less than one hundred and fifty thousand. Like the other encrinites (see fig. 44, p. 124.) it was provided with a long and powerful but moveable column, made up of a vast multitude of lozenge-shaped pieces (see fig. 51,) each marked with a curious set of indentations, and each pierced with a central aperture (52,) by means of which a communication was kept up during life, enabling the animal probably to attach itself to some marine substance, or a floating log of wood. In the Pentacrinite the stem (51, 52) was five-sided, and the body was partly defended by a small cup formed of regular plates rising from the column, and partly enclosed by a multitude of very minute and angular plates fixed on a tough membranous pouch terminating with an extensile proboscis. The body was surrounded also by an incredible multitude of branching arms, forming a complicated stony net-work, intended to intercept and convey to the stomach the particles of food fit for the animal, which were floating in the water within reach. Many specimens of this fossil are often found together, attached, it would seem, to what was once under surface of decayed wood drifting through the water.

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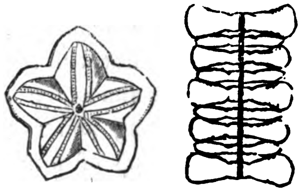
* So named probably from the appearance of the bed in riband-like *layers* of different colours observed in some parts of England.

Fig. 51 *Fig.* 52

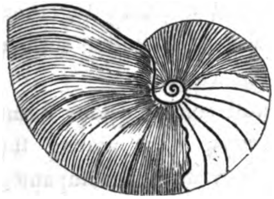


PENTACRINITE.
(Detached Piece and Section of the Stem)

Several varieties of star-fishes, and some curious forms not unlike certain recent crustaceans, were among the common tenants of the lias; and they were accompanied by a large number of animals inhabiting shells of various kinds, most of them very different from those known at present. Among these are both bivalves and univalves, the former including a good number of the Brachiopoda already referred to, and belonging to groups, such as Terebratula, still represented. The univalves, besides a considerable number having near relations with those of existing seas, include also a very large and important group, highly characteristic of the secondary period, and now absolutely extinct. I allude to the so-called *Ammonites*, the nearest analogue of which is the Nautilus, an animal most of whose peculiarities of structure are now known, although much has still to be learnt with regard to its habits. This animal (the nautilus) is almost our only guide in working out the various interesting points connected with the extinct but nearly allied group of which the ammonite is in some respects the most perfect type.

Reference has already been made, in speaking of the extinct forms of an earlier period, to the peculiar groups of cephalopodous animals whose remains are met with in the older rocks. Of these animals there are two well-marked groups represented at the present day, the one by the nautilus, and the other by the cuttle-fish. Of these, the former (see fig. 53) inhabits a univalve shell, divided into compartments by a kind of internal framework; but the latter is unprovided with any external defence and only has an imperfect skeleton, known in the common cuttle-fish as the *bone*. Of these two groups the former was abundantly present in the ancient seas, as we know by the fragments that remain of its solid stony habitation. The latter may or may not have been equally abundant, since from the nature of the case its remains could not be so frequently or so well preserved; but we know that various species referrible to it existed

Fig. 53.



NAUTILUS.

throughout the secondary period, and that one genus at least, now extinct, was then extremely common.

The nautilus is a remarkable and a very interesting genus, belonging to the most highly organized, not only of shell-bearing animals, but of all Invertebrata, and even exceeding some of the fishes in this respect.

It is one of the group of *Cephalopoda*,* or animals whose organs of locomotion are attached immediately around and upon the rim of the mouth or head. The fore part of the body forms a strong and wide sheath, each side of which produces a group of conical processes pierced with openings, through which prehensile organs or feelers are, at the will of the animal, projected or retracted. The sheath forming the base of these organs, which are used both for locomotion and prehension, is also a pouch, in which is contained the mouth and the eyes; and is, in fact, the head, containing what may be regarded as a true brain. The rest of the animal is immediately contiguous, and includes the stomach and other organs; and all the soft parts are enclosed in what is called a mantle or sac, a thick muscular skin, which keeps them together in their places and enables them to act in concert, but offers no defence against an external enemy.

The animal of the nautilus, thus constructed, having considerable powers of locomotion and a complex organization, was enclosed in a stony habitation somewhat resembling many common univalve shells. But such an appendage adds considerably to the specific gravity of the whole mass which, even without it, could hardly be lighter than water; and with it, unless by some special contrivance, would for ever remain at the bottom of the sea. The contrivance is a very simple one, and consists merely in a provision by which, as the animal grows in size, it from time to time builds off a cup-shaped wall upon the soft rounded surface of the hinder part of the body, leaving as it goes a space behind it, which is occupied only by air or some gaseous substance, and acts as a float.

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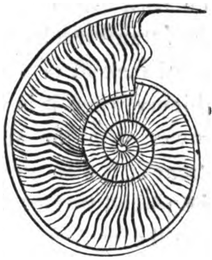
* See *ante*, p. 54. and p. 102.

Proceeding in this way, and building a succession of these walls, there is ultimately formed what is called a chambered shell; and all the chambers but the outer one, (that containing the animal,) being filled with air, are in a condition to support the body and shell in the water without sinking. A communication is kept up between the sac enclosing the heart (the pericardium) and the various chambers by a tube passing through all the walls in succession; and it has been supposed, although it is by no means proved, that this tube permits of a change being effected in the specific gravity of the animal, by forcing in a small quantity of fluid in addition to that which the tube generally contains.

The nautilus is a genus which has been almost universally distributed both in time and space, having been introduced at a very early period, existing apparently in all parts of the ancient seas, and continued in some shape or other even up to the present day. The Cephalopoda, as a group, are, however, chiefly characteristic of the first and middle epochs; and one form was greatly developed during the early portion of the period we are now considering. The genus *Ammonites*, the one here alluded to, may therefore be properly described when speaking of the lias fauna. There are, however, certain subdivisions of the genus as it now stands, which appear confined to beds of a certain age; and the annexed figure represents a group peculiar to the older part of the secondary epoch.

In the true ammonite the shell is spiral, and coiled on itself in one plane, the whorls at least touching, and not unfrequently enclosing one another. It differs from the nautilus in several respects, namely, (1) in the substance of the shell itself, which is generally, though not invariably, much thinner than in the latter genus; (2) in the form of the aperture and the relative proportion of the last or outer chamber; (3) in being frequently covered with numerous bosses, tubercles, ribs and other projections, which greatly ornament the shell, and of whose use we shall presently speak; (4) in the nature of the wall of separation between each two adjacent chambers; and (5) in the position of the *siphuncle* or tube communicating with the various chambers.

Fig. 54.

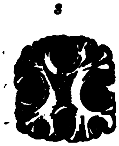


Ammonite of the Lias.
(Group *Falciferi.*)

The shell of the ammonite is usually thin, the outer chamber extends for about two-thirds or more of an entire whorl, affording a considerable space for the animal to inhabit; and the external aperture is often provided with very singular projections, or is swelled out, affording in all probability, a means of attachment, by which the animal was safely enclosed within its shell. But as this part seems to have been generally thin and fragile, it is rarely preserved in ordinary specimens.

To make up, perhaps, for the thinness of the shell, and to give additional strength without greatly increasing the weight, most of the different species of ammonites are ribbed and covered with tubercles, which, if we look upon the shell simply as a mechanical contrivance for defending a soft animal, and consisting of a continuous arch coiled round itself, served the purposes of transverse arches and domes. The external surface was greatly strengthened by such an arrangement, and the nature of the strength thus communicated it is not difficult to understand. The introduction of the ribs, which were distributed over the surface of the shell transversely, corresponds to the introduction of fluted metal instead of a plane surface, often made use of in machinery when it is wished to combine the greatest resisting power with the smallest weight of material. Additional strength is also gained by the bosses or elevations of part of the ribbed surface into dome-shaped tubercles; for these, like the vaultings in architecture, give strength to the surface to be supported, and are therefore usually placed at those parts of the external shell beneath which there is no immediate support from the internal walls which separate the chambers from one another.

Fig. 55



SEPTUM or Chamber-wall of an AMMONITE.

It is, however, chiefly in the arrangement and construction of these walls of separation (fig. 55,) that mechanical contrivance seems carried to its height in the shell of the ammonite; but here, also, the contrivance is exceedingly simple, and merely consists in causing the extremities of the walls, where they meet the shell, to deviate into a variety of ramifications and undulating lines. This is singularly shown in the progressive change by which the *Nautilus* (fig. 53, p. 142,) where these lines of intersection are nearly straight, is succeeded by the *Clymenia*, where they are decidedly curved; then by the *Goniatite* (fig. 40. p. 103,) where they become angular; then again by the *Ceratite* (fig. 45, p. 124,) where they are rounded and exhibit a tendency to undulations; and lastly by the *Ammonite*, in many species of which[*] the sinuous windings of these sutures, at their union with the external shell, are singularly complicated and beautiful, adorning it with a succession of most graceful forms, resembling festoons of foliage and elegant embroidery; so that when, as is often the case, these thin septa are converted into iron pyrites, their edges appear like golden filigrane-work, meandering amid the pellucid spar that fills the chambers of the shell.*

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[*] See figs. 102, 104, where are represented closely allied forms, in which the nature of the intersection does not differ from that observed in the most typical ammonites.

The mechanical advantage of this contrivance is considerable, and arises from there being many more points supported in the case of a wall of this kind, than by a plain surface, the cause of which will readily be seen in the woodcut annexed (fig. 55.) The main object of the empty chambers in all animals that possess them, is to serve as floats buoying up the animal and its shell, and reducing the specific gravity of the whole mass to that of water; and the vacant space in the shell answering the purpose of a float, must be divided into closed compartments, because it is built at successive times as the animal grows and requires additional support.

The position of the siphuncle—as the tube running through the whole series of chambers is called—is another and not unimportant peculiarity in the ammonite. In the case of the nautilus this tube is of tolerably large size—often thicker than a quill—and it passes through the middle of the septa or walls into the pericardium of the animal. In the ammonite (fig. 55, *s*) it is often exceedingly small, and always situated quite on the outside of the shell. Whatever may be the use of the siphuncle in the nautilus, and that use is by no means clearly determined, there is no proof that it could have assisted to raise or sink the animal in the water in the case of the ammonite.

The cephalopods we have hitherto considered form a group differing from the common cuttle-fish in some important anatomical characters, and having an external shell into which they could retire. They also differed in the absence of any defensive contrivance like that possessed by the cuttle-fish, which is known to emit an inky fluid in order to escape from its enemies. It is probable that all those species provided with chambered shells belonged, like the nautilus, to the less highly organized division of the Cephalopoda, the animals of this group, as is the case with the other shell-clad mollusca, being generally too well protected to need any means of temporary concealment. They were doubtless able to shelter themselves completely within their houses of stone; and it is not unlikely that the very act of retirement into its shell would tend to sink the animal, by diminishing the quantity of surface exposed to the water.

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* Buckland's Bridg. Tr., vol. i. p. 347.

But there exists another group of cephalopods besides those provided with shells, and comprising animals of higher organization; obeying in this respect the law which I have already had occasion to notice, that animals having defensive armour are, on the whole, not so high in the scale of beings as those which resemble them in other points of structure, but whose bodies are naked and apparently more exposed to danger.

That division of the Cephalopoda which approximates most nearly to the Vertebrata comprises several families, of one of which the common cuttle-fish is an example. Another form, still more remarkable, is met with in a fossil state, and includes a vast number of species strictly confined, like the true ammonites, to the secondary period. It is known by the name of *Belemnites*,* and is a most characteristic and abundant genus.

The cuttle-fish has been already described as possessing a kind of calcareous skeleton, so ingeniously contrived, (being formed of numerous stages of thin calcareous plates, kept apart from one another by the interposition of millions of microscopic pillars,) as to serve as a float instead of impeding the motions of the animal. Rendered in this way as light as the water in which it dwells, the animal moves rapidly along, either backwards by forcing water through a tube, or forwards by the aid of a long pair of flat, broad tentacles, projecting beyond the eight arms which surround its head. At the approach of danger it is enabled to sink suddenly; and at the same time it throws out, from a singular receptacle called an ink-bag, a quantity of dark-coloured fluid, in the obscurity caused by which it is better able to escape from its enemies.

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* Βελεμνον (*belemnon*,) a dart.

The belemnite has been long known as a solid calcareous fossil, of a conical shape, more or less elongated; and it was also known, that, while the pointed end of this fossil was solid, the other extremity enclosed a number of plates like watch-glasses, fitting into a conical hollow. Specimens too had been found, especially in the lias, where a considerable portion of thin horny sheath extended beyond the ordinary termination of the shell, and beyond the conical receptacle of the plates. The belemnite, in fact, was known to consist of a chambered shell, like the Orthoceratite, contained in another shell of curious structure, and had been supposed to belong to an animal like the nautilus.

The first evidence by which any direct light was thrown on the nature of the animal provided with this shell, was detected by Dr. Buckland and M. Agassiz, who examined some specimens of belemnite, in which a fossil ink-bag, and the duct or pen by which the ink was shot out into the water, was preserved in the outer chamber of the shell. It must be remembered that the ink-bag has not been found in any specimen of ammonite or nautilus, and is apparently a necessary adjunct to the naked cephalopods of high organization; so that, on this discovery of its presence in the belemnite, it became probable that the shell had been internal, and that the animal belonged to the group of more highly organized Cephalopoda, and not that in which the nautilus and ammonite were classed.

After this discovery of the ink-bag, it seemed that little more could be expected in the way of determining the habit of the belemnite, till it was also made out from specimens in foreign beds that the animal must have extended considerably beyond the shell. Fortunately, however, in some specimens recently obtained,* not only the ink-bag, but the muscular mantle, the head, and its crown of arms, are all preserved in connexion with the belemnitic shell, while one specimen exhibits the large eyes and the funnel of the animal, and the remains of two fins, in addition to the shell and the ink-bag. We are thus furnished with distinct proof of the true nature and analogies of this singular creature, and we learn from ocular evidence that it combined the characters at present divided between three distinct genera. It possessed a calcareous, internal, chambered shell, like the *Sepia*; it was provided with a formidable apparatus of hooks upon the arms, characteristic of the modern genus *Onychoteuthis* (the most powerful and rapacious of the cuttle-fish tribe, and the one provided with the most singularly powerful and complicated contrivances to ensure the destruction of its prey;) and, thirdly, it had the peculiar attachment of the fins, in a position a little in advance of the middle of the body, seen in the *Sepiola*.

The belemnite, having the advantage of a dense but wellbalanced internal shell, must have exercised the power of swimming backwards and forwards with great vigour and precision. Its position no doubt was generally vertical; it would rise swiftly and stealthily to fix its claws in the belly of a fish, and then perhaps as swiftly dart down to the bottom and devour it. On the approach of danger, it could suddenly shoot out its black inky fluid, and hide itself from an enemy; and whether we consider the large dimensions it attained, its muscular energy, its singular contrivance of hooks in connexion with powerful suckers, its powers of locomotion, or its facility of concealment, it must have been the most formidable and predaceous animal of its class, and has probably never been excelled in strength or vigour by any of the Invertebrata.

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* These specimens are from the Oxford clay, and the animal and its shell will be again alluded to and figured when treating of the fossils of the Oolitic period. It is referred to here as being a common lias fossil, and as one of the early and most remarkable associates of the ammonite.

The ammonites and belemnites are both so characteristic of the lias, and so remarkable in themselves, that they claimed some detailed description in an account of the various groups of animals of that period, no longer existing upon the earth. They seem to have chiefly abounded, or at any rate are most commonly preserved, in those beds of the secondary epoch which indicate a moderately deep sea with a muddy bottom, and their remains are then so abundant, as to form in some cases complete strata of themselves. They may indeed be said to equal in number the Orthoceratite remains in the older rocks; but the ammonites were in reality the representatives of these straight but external shells, the belemnites being superadded and of higher organization.

Besides the fragments of shells, and other remains of invertebrated animals already described, we find also in the lias a very abundant supply of Ichthyolites,* or fossil remains of fishes of various kinds, the most abundant of them belonging either to a peculiar family of sharks, or to tribes characterized by their coating of enamelled scale and bone, and the entire absence of true skin. Of the former of these fishes we only find the teeth and the remains of peculiar spines.* (*Ichthyodorulites*, fig. 56) which had been attached beneath the skin in the flesh; so that there are no very certain grounds by which we can deduce the details of structure, or even the form of the species, and the general dimensions to which it attained. But the spines just alluded to are very interesting fossils, and require further description, since remains of this kind are exceedingly numerous and varied, and their use is known to us from the examination of a shark confined at present to the seas which wash the shores of Australia.

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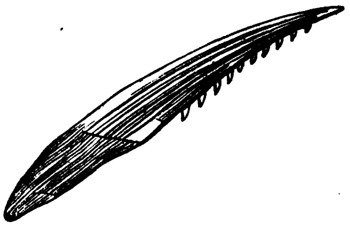
* Ιχθυς (*ichthys*, a fish; λιθος (*lithos*, unde *lite*,) a stone. The termination *lite* is constantly made use of in Geology to indicate a fossil body.

Fig. 56



ICTHYODORULITE.

In this animal, which is called the "Port Jackson Shark," the general form of the tribe to which it belongs, the position of the mouth on the under side of the body, the habit of extreme voracity, &c., are all retained; and in order, as it would seem, that it may possess an unusual facility in turning itself in the water to take its prey, (which can only be done when the mouth is uppermost, and the body therefore inverted) there is added to the ordinary apparatus of fins, a moveable one on the back, of considerable dimensions, worked by a spine—a kind of mast—which is inserted simply, but deeply, through the skin into the flesh, and is elevated when necessary by a muscular effort. When this spine is elevated, it lifts with it the fin, and instantly begins to act, assisting and rendering more rapid the turning of the whole fish. It is a curious fact, that the structure of these spines, as seen under the microscope, is hardly to be distinguished from that of teeth; and in this way, an almost anomalous contrivance, introduced, doubtless, for a special purpose, is found to resemble a totally different organ, adapted for purposes altogether distinct and peculiar. The spines may also have served as defensive weapons, but are not likely to have any thing to do with ordinary locomotion. They produce a sudden and considerable impulse corresponding to the great muscular energy of these creatures, and prevent the delay that would necessarily arise if the animal had to check its motion through the water while pursuing and when in the act of capturing its prey. Spines on the backs of sharks are not confined to one genus, but seem to have been common appendages to the dorsal fins of most of the ancient species. Being hard, indestructible, and readily detached after death, they have often been preserved in a fossil state; and from their variable markings, deep furrows, and hooked teeth, we are able to determine a large number of species of these long extinct animals. Unfortunately, since the teeth—almost the only other hard part of sharks—are not found directly associated with the spines, we may probably often describe and name the same species twice over, especially when the specimens are from the same strata, since we are not in a condition to determine the relation that may have existed between the two kinds of organic remains. The sharks of the lias attained a large size, and were exceedingly abundant and voracious.

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* See *ante*, p. 107.

The other fishes of the lias, most remarkable for their number or peculiarity of form, are of much smaller size, and belonging to another order. They are also so completely enclosed in coats of mail, that their perfect form is handed down as frequently as the teeth and spines of the others. A fish called *Dapedius*,[*] from the regular manner in which the large scales are arranged, like a paved surface, on the back, is exceedingly common in the lias in some parts of England, and must have been very abundant. It had a wide, flat, and broad body, covered with large, regular, and nearly square scales, coated with enamel, and a regularly formed tail, of which the scales were oblong; but one of its most striking peculiarities consisted in the form of the bones of the head, the jaws being short, and the lower one broad, and almost as high as long, while its fore part was depressed towards the middle, to receive the upper jaw. These and the other bones of the mouth, and the whole of the palate, were thickly covered with many successive rows of teeth, gradually becoming smaller as they receded within the cavity of the mouth. All the external bones of the head were thickly coated with hard and bright enamel strongly marked with granulations. These bones were quite naked, neither flesh nor skin being needed for a surface so defended.

Besides a large number of species of this and a closely allied genus (*Tetragonolepis*,)[†] there were many others also provided with enamelled scales, and a good number of representatives of the family of sauroid fish, although the latter did not attain the magnitude or importance that they possessed in the more ancient seas. The *Pachycormus*,[‡] however, of which there are at least nine species found in England (chiefly at Whitby,) must in some cases have been a most formidable animal for it grew to a considerable size, and was provided with powerful rows of sharp teeth; while the *Lepidotus*, belonging to another group, was represented by ten lias species, and a still greater number of oolitic ones, and, although not so large as the Pachycormus, was doubtless an important fish. A restored representation of the latter genus is given in the next chapter.

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[*] Δαπεδον (*dapedon*,) a pavement.

[†] From the shape of the scales: *τετραγωνος* (*tetragonos*,) quadrangular; *λεπις* (*lepis*,) a scale.

[‡] Παχυς (*pachys*,) thick; *κορμος* (*kormos*,) a block or stump: from the clumsy appearance of the fish.

Among the other lias fishes, there were one or two very remarkable *Rays*, one of them supposed to have possessed some curious analogies with the sharks: these are of moderately large size, but, as might be expected with an animal whose skeleton is so soft, the remains are extremely rare, but the knowledge of their existence is a very interesting point. The form of the scale of this fish is represented in fig. 21, p. 71.

On the whole, it does not appear, either from the general character of the lias invertebrate animals (such as the encrinites, the crustaceans and the molluscs) or from the fishes, that this deposit took place in deep water. We might conclude rather, both from the general character, and also from the nature of the bed, and the vast abundance of fossils in particular spots, that it was a rapidly forming shoal, or mudbank, or perhaps a great bay like the Yellow Sea, with land at no great distance, the resort of a vast number of such animals as commonly inhabit localities of that kind, and also of the predatory and voracious races that pursue and devour them. Let us turn now to the consideration of the animals of higher organization, and endeavour to learn from their remains, so far as they are handed down for our investigation, how far they will help us to determine the problem of the true nature of the lias fauna.

Reptiles, as they exist at present, are conveniently grouped into five principal subdivisions, characterized respectively by the crocodiles, the lizards, the tortoises and turtles, the serpents, and the frogs. Among these, there are none which are so organized that the open sea can be called their chief habitation, none are provided with any apparatus by which they can support themselves in the air like birds, and none exhibit a distinct connecting link with the quadrupeds, by the possession of such locomotive organs as raise them above the ground in any proportion to their absolute magnitude. The whole number of species of these animals now known is also not very considerable, and they can hardly be said to perform a part of great importance in the economy of the globe.* We have already stated, in the account of the palæozoic period, that interesting examples of these animals had already been introduced amongst the inhabitants of our globe, and that the lacertian type—that exhibited in the lizards of the present day—had been selected, with certain modifications, as the model of structure. We also found that not only was this lizard type continued with a very remarkable bird-like modification during the triassic or new red sandstone period, but that it was then also represented by a curious and gigantic group of animals, whose analogies point rather to the frog and salamander than to any other existing reptiles, although some species attained the dimensions of the crocodile, and exhibited also points of affinity to that higher group.

But the new red sandstone, or rather the shelly limestone occurring in the middle of the sandy beds of that formation on the Continent, also contains some fragments, not only of teeth but of bones, which indicate very distinctly the presence of a crocodilian animal, whose extremities, being reduced almost to the condition of paddles, could not have allowed the creature to walk about readily on land. It was, doubtless, an aquatic form; but as the crocodile of the Ganges and some of the alligators of the present day are also aquatic, there is in this no absolute departure from a known and recognised reptilian habit.

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* Animals of this kind appear to be chiefly abundant, and to attain the largest dimensions. in those hot districts, chiefly intertropical, where the banks of large rivers are occasionally overflowed, and where extensive tracts not much raised above the sea level are sometimes clothed with rich vegetation, sometimes consist of bare hard clay and sometimes of soft mud. The larger crocodiles and alligators especially inhabit the muddy districts: in the rainy season they appear and range about, preying on the various animals that approach the water; but in the hot dry season they retire, and become so coated with hardened mud, as even to escape being seen by the traveller.

It still remains to be seen how far this *Nothosaurus*,* as it is called, a spurious kind of saurian, was related to the crocodiles, and whether it formed a passage into a group differently characterized, and so constructed as to live almost exclusively in the sea, obtaining there only the means of subsistence.

Such a group existed at the time of the deposit of the lias, and is there represented by two genera perfectly distinct from one another, each exhibiting several well-marked species, and both present in most extraordinary abundance. The perfect skeletons of various species belonging to each genus have been occasionally found embedded in the rock, and other specimens have been obtained in all degrees of preservation; so that it is clear that the animals must have lived long and multiplied greatly in the seas which covered a great part of what is now land in the northern hemisphere, shortly after the completion of the deposit of the new red sandstone.

The most essential character in these animals, is that they were exclusively marine in their habits; not merely taking refuge in the water occasionally, like most of the crocodiles, or seeking their prey there, and then, when gorged, coming ashore to sleep in the marshes and jungle; but adapted in all respects to make use of the sea as their permanent habitation, and only resorting to land from time to time, probably to deposit their eggs, which would afterwards be hatched by the sun.[*] They formed a distinct group, having the same relation to other reptiles that the animals of the whale tribe bear to other mammals; exhibiting in all essential points the structure of their order, but yet having this structure so adapted as to permit the animal to live in a different element. We shall see presently the kind of modifications made use of for this purpose.

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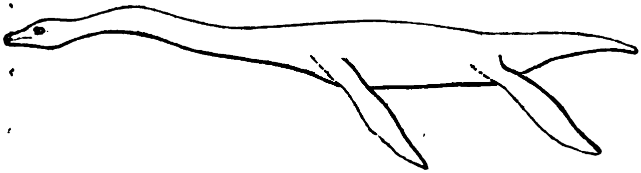
* Νοθος (*nothos*,) illegitimate, or spurious; σαυρος (*sauros*,) a lizard.

The PLESIOSAURUS[†] is the name given to the one of these animals we shall first describe. The name is applied in consequence of its offering in many points strong analogies with the other reptiles; but these are not sufficiently close to prevent it from exhibiting a form most strange and anomalous, and a structure equally remarkable, and differing considerably from that of any other animal.

Fig. 57.



RESTORED OUTLINE OF PLESIOSAURUS.

The most striking and manifest peculiarity in the Plesiosaurus consists in the enormous length of the neck, which, in some species, not only exceeds in absolute dimensions, but also in its proportion to the size of the animal, that of the longest-necked quadruped or bird. But the perfect mobility of this neck, of which we may form an idea by the number of joints it possesses, was no less remarkable. The giraffe, the longest-necked quadruped we are acquainted with, has only seven vertebræ of the neck, not differing in this respect from the other mammals; the swan, the longest-necked bird, has twenty-three: but the Plesiosaur is known, from some admirably preserved specimens, to have had upwards of thirty, and perhaps as many as forty. In its proportions, the neck in one species measures four times the length of the head, and actually exceeds the entire length of the body and tail. It was apparently thick and muscular near the body, but gradually became slender towards the head, which was small, and sometimes singularly disproportioned in size to the other parts of the animal.

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[*] It is not indeed certain that these animals were oviparous, but this must be considered the most probable conclusion, at least without better evidence to the contrary than has yet been presented.

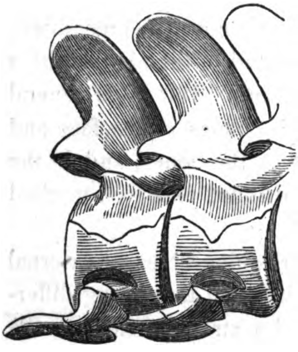
[†] Πλησιον (*plesion*,) near or resembling; σαυρος (*sauros*,) a reptile.

The head thus reduced in size exhibits, however, rather a high type of organization. It offers some of the peculiarities which characterize the lizard, especially in the wide interspaces left between the bones; in the existence of a strong crest along the middle of the skull, indicating that the jaws were worked as in lizards and not as in crocodiles; in the structure of the lower jaw; and in the absence of a cross ridge on the fore part of the skull. But in its general form, in the strength and size of the bones of the face and jaws, in the rugged outer surface of the bones, and in the sockets of the teeth, there is a distinct and well-marked approximation to the crocodile.

In the size and position of the breathing-holes, or external nostrils, we find, however, a marked and interesting difference from all existing reptiles, and a strong analogy to the corresponding part in animals allied to the whale, offering a beautiful example of adaptation of structure presented in very different animals, but producing similar results and supplying similar exigencies. These apertures are placed near the highest part of the head, where they would enable the animal most readily to breathe, without exposing any thing more than the apertures themselves above the water, corresponding admirably with the marine habits of the animal, as indicated by the structure of its extremities.

The jaws of the Plesiosaur are strong and rather spoon-shaped; they were provided with a large number of teeth—probably not less than a hundred—which were conical, slender, long, and pointed, slightly bent inwards, and deeply grooved. These teeth had long fangs, and were planted in separate sockets, as in the crocodile. They could also be repeatedly and indefinitely renewed. It is probable that the animal could, like some serpents, swallow prey actually larger than the size of its head, the bones being so little attached that the cavity of the mouth could become greatly dilated by a violent effort. There can be no doubt that the habits of the animal were strictly carnivorous.

Fig. 58.



VERTEBRÆ OF PLESIOSAURUS.

The long neck, gradually swelling as it receded from the head, and provided with false ribs, passed perhaps almost insensibly into the body, which, though of small size, is exceedingly compact and strongly put together. The back-bone, from the neck to the commencement of the tail, includes from about twenty-five to thirty vertebræ (fig. 58,) which like those of the neck, present to each other nearly flat surfaces; and the tail, which was of moderate length but very powerful, had an additional twenty-five, also flattened in a similar way. All the vertebræ had strong and large processes or projecting plates of bone for the attachment of muscles (see fig. 58.)

The trunk and extremities of this singular animal present many points of interest, especially with regard to contrivances introduced to meet the wants of a marine reptilian animal.

The ribs of vertebrate animals are, properly speaking, appendages to the vertebræ, one pair being usually developed from each vertebra, to approach or meet on the under side of the animal. The Plesiosaurus, however, was provided with sets of bones, each set consisting of seven, which connected these free extremities, rendering them very strong, but also allowing a considerable amount of play, since the connecting bones could slide upon one another. This contrivance admitted of much greater expansion of the lungs than is common in reptiles.

The portion of the body corresponding to the breast-bone, and connecting the four extremities with the vertebral column, is strong but not complicated, and appears better adapted for allowing free motion in the paddles, and so propelling the animal through the water, than for supporting the weight of the body on land. Nearly the same may be said of the pelvis, which supports the hind extremity, and which exhibits about a corresponding degree of strength. There is also a beautiful contrivance enabling the animal to make use of its extremities to some purpose even on land, and in this respect the Plesiosaur was indeed much better provided than the seal.

The extremities themselves do not differ very greatly from those of some of the cetaceans, but they were longer, more tapering, and seem to have possessed greater flexibility. There are stout and moderately long bones corresponding to the shoulder and thigh bone, a couple of short and flat bones which represent the bones of the fore-arm and the lower part of the leg, and then a succession of bones, oblong and flattened, and extending to some distance, which were enclosed entirely within the skin during the life of the animal, and which formed the solid part of the paddle.

There are several very distinct varieties of form in the different species of Plesiosaurus, and amongst them are some in which the head is far larger in proportion, the neck shorter and thicker, and the body more expanded. Others again are remarkable for the large dimensions of the paddles; and others for different modifications of structure, but all agree sufficiently in the principal characters, and teach us with equal distinctness what were the general habits of the animal. The specimens indicate also very different sizes; but, since in all reptiles the limit of growth is much less strongly determined, and the increase much greater, than in more highly organized animals, it will be sufficient to state that the largest complete specimen yet found is about eighteen feet in length, but that there are fragments of individuals which would seem to have been nearly twice as large.

The Plesiosaurus was highly carnivorous in its habits, and no doubt fed indiscriminately on whatever came within reach, whether living or dead. Its powers of locomotion in the water were great, and its strength must have been formidable; but it had an enemy in the *Ichthyosaurus*,* from which there was probably little chance of escape. We have good reason to suppose that it could move about on shore, and it probably did so with greater facility than the seal or walrus; but it is not likely that it resorted frequently to the land, since the sea appears to have been its more congenial habitat.

The animal just mentioned as the fierce and powerful enemy of the Plesiosaurus, which was itself a voracious reptile attaining a length of from ten to thirty feet, belongs unquestionably to a most remarkable and anomalous genus, but departed, perhaps, much less considerably than the other from the present external form of marine animals. With the exception of a larger head, and paddles somewhat more developed, it was not very unlike the porpoise in its appearance, but it was a true reptile, adapted for constant residence in the sea, and in that respect claims comparison as being the ancient analogue and representative of the great existing tribe of marine mammalia, of which the whale is perhaps the best known type.

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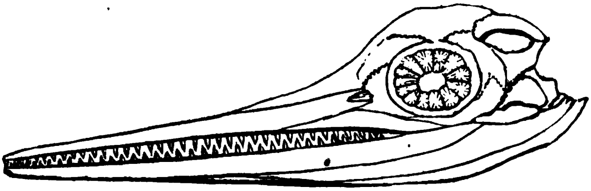
* Ιχθυς (*ichthys*,) a fish; *σαυρος* (*saurus*,) a reptile.

The head of the Ichthyosaurus was in all cases large compared with the general proportions of the body, and in general form it resembled that of the dolphin, the chief part of its magnitude consisting of a greatly elongated snout, like that of some of the aquatic crocodiles of the present day. The jaws are long, comparatively slender, and tapering to the extremity. Along their whole length on both sides there is a continuous row of conical teeth of large size, not inserted in separate sockets, but placed in a kind of trough cut in the jaw, and merely separated from one another by a ridge of bone. These teeth were constantly removed and replaced by new ones during the whole life of the animal.

Fig. 59.



ICHTHYOSAURUS.
(Side View of the Skull.)

The structure of the lower jaw indicates a mechanical contrivance of some interest, intimately connected with the wants and habits of the animal. The jaws themselves are, as we have seen, long and slender. The teeth show that the animal was fierce and voracious, and analogy teaches us that in such cases the jaws must close suddenly on their prey with a snap, in order to ensure a proper hold being obtained. But a slender lower jaw, however strong, would be very easily broken when brought in contact with hard bodies, such as the solid enamelled plates enclosing some of the fish of the liassic period. By a complicated apparatus of several pieces of bone, arranged so as to distribute in some measure the necessary shock arising from the convulsive jerk made while the animal was in the act of seizing its prey, we have this purpose effected in several of the existing reptiles; but something more than this seems to have been needed by the Icthyosaur, since it exhibits an example of cross bracing, adding greatly to the effective strength without increasing the weight. By simply introducing a change of direction in the grain, as it is called, or fibre of the bone, this purpose is accomplished, so that the animal was enabled to snap with safety at the hardest and most solid substance that came within its reach. The jaws of some specimens must have been upwards of six feet in length.

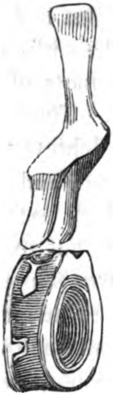
The most remarkable peculiarities in the head of this fish-reptile besides the jaws are the size and structure of the eye, the smallness of the brain, the separation of the different bones of which the skull is made up, and the position of the nostrils.

The orbital cavities which contained this eyes are of immense size, their circumference including several distinct bones (see fig. 59,) and provided with plates of bone partly covering the eye, and overlapping one another so as to leave a variable aperture for the pupil. There are instances in which these orbits are eighteen inches across, or, in other words, so large, that it would require a string of nearly five feet long to surround the cavity of the eye.

The eyes were placed far back on the head and behind the snout, with the nostrils or breathing holes just in front, so that each time that the animal came to the surface to breathe, the eyes and nostrils, but no other parts of the head or body, would be brought into the air. There can be no question that a voracious animal like the Ichthyosaur, obliged from time to time to appear above water, and perhaps occasionally to come on shore, required an extraordinary provision, enabling it not only to see, but to see distinctly, every thing passing around it. It was thus provided with a peculiar apparatus, enabling it to adapt its vision not only to shallow but to deep water, and not only to water but to air. This apparatus effected its purpose by permitting a change of shape of the pupil of the eye, according as circumstances required; the pupil dilating at great depths, where but little light is transmitted, the shape flattening to allow of distant vision on shore, and the whole eye pushed forwards to enable its owner to see objects close at hand, thus affording every variety of action to this important organ. The bony scales which enclosed and defended the soft ball of the eye most resemble what is seen in the golden eagle and some other birds of prey, and may be best understood by a comparison with the scales of the artichoke. The structure is characteristic of reptiles rather than of fishes, and amongst reptiles is most remarkably shown in the lizard tribe.

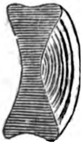
The head was connected immediately with the body in the Ichthyosaur, the neck being scarcely perceptible, as is the case with fishes and whales. The back-bone, which is thus almost directly attached to the skull, is made up of about fifty double concave vertebræ (fig. 60,) exceedingly unlike those of any land animal, but nearly resembling the corresponding parts of fishes, though at the same time clearly distinguishable. It may be necessary to remind the reader, that in quadrupeds generally, and in birds, these vertebræ not only present flat surfaces to one another, but are more or less firmly connected by the interlocking of projecting bones or processes. In the reptiles generally there is a recess on one side of each surface, consisting of a cup-shaped hollow into which a corresponding ball of the adjacent vertebra fits and works. In the Plesiosaurus, as I have already described, this is absent, and the bones present simple, flat, or very slightly doubly concave surfaces to each other; but in the Ichthyosaurus and in fishes the two cup-shaped hollows are deep and strongly marked (figs. 60, 61,) so that there was considerable interspace between the centre of two adjacent vertebræ. This interspace is filled with fluid in the case of fishes and the Ichthyosaur, allowing of those minute but incessant and very important lateral motions by which the fish, supported and floating in the water without effort, moves itself readily in every direction. In this respect, therefore, the Ichthyosaur had the advantage of all reptiles, for, being an inhabitant of the sea, it was provided with the same power of ready motion and great flexibility as the fishes themselves.

Fig. 60.



ICHTHYOSAURUS.
(Vertebra.)

Fig. 61.



But still this strange monster was a reptile. To the vertebræ thus constructed were attached not only true ribs, but a continued series of them along the whole length of the body, enclosing the great cavities of the heart, abdomen, &c., with a perfect vaulting of elastic bone. Across the chest these ribs are connected by intermediate bones, each set consisting of five, overlapping each other as in the Plesiosaur, and doubtless performing a similar office.* But in the Ichthyosaurus the breast-bone to which these ribs were attached presents some peculiarities exceedingly remarkable and characteristic.

In the whale tribe the breast-bone is developed so as to enclose the complicated apparatus of lung necessary for air-breathing warm-blooded animals, having a complete circulation; but in the true marine reptiles this is by no means the case, and we find that, although this apparatus of the breast-bone is present, it is so in order that it may form a support and a point of resistance to the fore-paddles of the animal.

In this respect again there is another curious analogy between the Ichthyosaur and the Duck-billed Platypus or *Ornithorhynchus* of Australia, one of the most anomalous of living animals, which seems to require the same kind of contrivance, and possesses it in a nearly similar manner.†

The hinder extremities, although strong, do not exhibit any special contrivance, and were not attached with unusual strength to the back-bone and the sacrum, so that it appears that the habits and necessities connecting this creature with the fishes have been here chiefly considered. The hinder extremities are also usually smaller than the others. In serpents we have a similar arrangement; but in that case the extremities are merely rudimentary, and are of no use to the animal in locomotion.

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* Nineteen pairs of ribs have been found thus connected in one specimen of Ichthyosaurus from Lyme Regis.

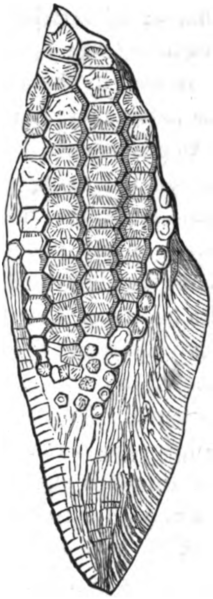
† The bones which correspond to the shoulder bone are articulated to a short and stout scapula (shoulder blade) like that of birds; the fore part of this is fixed both to the clavicle (or collar-bone,) and to the bone corresponding with the breast-bone, while the other receives the extremity of the humerus (shoulder-bone,) and is also attached to another bone proceeding from the blade-bone, and in man merely forming a projecting surface upon it. These latter bones again also articulate with the breast-bone, so that there is a double attachment, rendering the whole more secure, and providing a resisting surface, against which the extremities may safely press with the whole weight of the animal, without these parts yielding inwards and pressing against the soft muscular masses.

The paddles or fins by which the Ichthyosaurus made its way through the water are very curious and interesting, for they are perhaps more perfect modifications of the true fish structure to the habits of an animal occasionally coming on shore, than any that can be referred to in nature. They at the same time exhibit the true reptilian structure of the animal, and thus show us how perfectly and yet how simply the legs of a quadruped and the fins of a fish are still formed according to a similar law of development, although intended for such different purposes, and presenting such very different appearances.

We have already considered the peculiar apparatus by which the paddles are made to rest upon the back-bone by means of a sternum or breast-bone affording a resisting power, but not connected with the ribs. It remains now to consider the form and structure of the fin or paddle itself.

The shoulder-bone, already alluded to, works upon a kind of blade-bone, but is not fitted into a deep socket. Its form somewhat resembles that of the corresponding bone in birds; and this bone, as well as the two which represent the fore-arm, are distinct, but very short and broad in proportion to their length, especially the two latter, which are often nearly round, and sometimes broader than they are long. Then come a number of small round bones, which represent those of the wrist, and complete two ill-defined rows. After them succeed a multitude of little bones (see figure,) arranged in distinct rows and fitting one another, but not exhibiting any mark of that division into fingers, which may be traced in the skeleton even of the most aquatic of the mammalia. The bones increase in number as they diminish in size, to the termination of the paddle. They form from three to six series, and are so dove-tailed together as to constitute an uniformly resisting framework, acting as a simple oar.

Fig. 62



ICHTHYOSAURUS.
(Restored Paddle.)

Such was the skeleton of this fin, or paddle, as made known by various examples, some of them quite perfect; but we are fortunately in a condition to tell yet more of its structure, and thence deduce more clearly the habits of the animal. In one specimen of the paddle (fig. 62,) obtained from Barrow-upon-Soar, in Leicestershire, not only the bones, but the actual outlines of the extremity of the fin, are clearly defined, and are found to exhibit the impression of a number of rays extending downwards and forking off towards the end. It is clear, from the extreme rarity of their preservation, that these rays were not bony, and they were probably either cartilaginous, or formed of that albuminous horn-like tissue, of which the marginal rays of the shark's fin consist. The fore part of the fin was terminated by a small unbroken and well-defined line, probably only a thickening of the skin; and the dimensions of the soft part, compared with the skeleton, show that the total length of the extremity would be about half as much again as that of its bony and solid portion.

The tail of the Ichthyosaurus was of great length, the number of vertebræ extending beyond the hinder extremities being very much greater than half the whole number possessed by the animal. At about the 30th vertebra from the pelvis there have been observed, in most of the more perfect specimens, distinct marks of a fracture, this portion of the tail being generally bent off at an angle. At the same point, too, there is generally a slight displacement of a few of the bones. This, however, is not all. At the point thus indicated a modification of the form of the vertebra has been observed, so that the rest (forming the tail) have a somewhat oblong shape, just the reverse of what is known to occur in the whale, where these bones are a little flattened. Now in the whales there is a powerful horizontal tail, by the beating of which up and down against the water, the animal is enabled at once to sink or raise itself in the water with extreme rapidity and force; but the only indication of such a tail in the skeleton consists of this slight flattening in a horizontal direction. From the position and regularity of appearance of the fractured tail of the Ichthyosaurus, and from the shape of the vertebræ, it has been concluded that this animal was provided with a long vertical tail, like that of fishes;* and, as we know that it was amply provided with paddles which would enable it to rise or sink very readily, such a tail would be of the greatest possible utility in producing rapid motion through the water—a power possessed to an almost incredible extent by some of the larger and more voracious fishes, such as the shark, and one which in them transcends any locomotive power that man has yet been able to attain, exceeding even that which birds possess in their familiar element, the air. It should not be forgotten that a powerful vertical tail would be almost necessary to the Ichthyosaurus to enable it to turn with precision and rapidity, so that its elongated head should be able to make a sudden and sure seizure of the anticipated prey.

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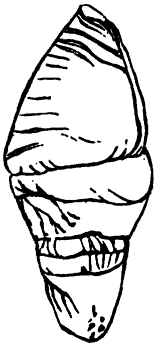
* After the death of the animal the vertebral column would very soon tend to fall asunder, owing to the absence of connecting processes, and the deep interspaces filled with fluid that existed between each pair of vertebræ. The mere weight of a vertical tail falling on one side would thus drag with it a portion of the bony series, and produce the dislocation so often observed.

Having now mentioned successively the most striking peculiarities of each part of the skeleton of this animal, and having even drawn conclusions with regard to such parts as the cartilaginous fins of the paddle, and the position and shape of the tail, or rather tail-fin, the reader will naturally conclude that the subject is exhausted, and that it remains only to sum up into a general view these various details. But the case is not so. We have seen that in this bed of fine mud, the bodies of animals were deposited and preserved so completely, that the skeletons, after the soft parts had decayed, retained their relative position, exhibiting all the important points of structure. Circumstances, however, sometimes occurred by which individuals, overtaken perhaps by sudden destruction, have been at once embedded, a perfect cast being formed of every part, internal as well as external, so that the skin, the contents of the stomach, its proportional magnitude and other details, may be learnt by careful study of the specimens thus embalmed and handed down to us. But, before dwelling upon these obscure and minute points, there are others to be mentioned scarcely less curious, resulting from the continued resort of great families of these monsters to particular spots. Possibly these spots may have been good feeding-ground, and favourable for the development of the larger mollusca and fishes, or the presence of shallows and neighbouring land may have been especially advantageous for breeding; but, at any rate, it is certain that we find, here and there, localities where vast multitudes of pellets of an oval shape and various size are accumulated. These pellets often contain fragments of bone, teeth, or fish scales, and are now recognised as being beyond question the fossillized dung of the great marine reptiles. They are spoken of by Geologists under the name of *Coprolites*,* or dungstones (fig. 63.) From the examination of these fossils it is easy to determine the nature of the food of the animals and some other points; and when, as happened occasionally, the animal was killed while the process of digestion was going on, the stomach and intestines being partly filled with half digested food, and exhibiting the coprolites actually *in situ*, we can make out with certainty, not only the true nature of the food, but the proportionate size of the stomach, and the length and nature of the intestinal canal.

Fig. 63



COPROLITE.

Within the cavity of the ribs of an extinct animal, the palæontologist thus finds recorded in indelible characters some of those hieroglyphics upon which he founds his history. He learns, that of this animal, manifestly well adapted for the most predaceous habits, the stomach formed a pouch of prodigious size, extending through nearly the entirec avity of the body. It was therefore of a capacity well proportioned to the powerful jaws and teeth which were admirably and beautifully contrived to supply its wants. With this enormous stomach, there was, however, very little room for a corresponding intestinal canal, and it is interesting to find the shape of the coprolites distinctly showing that this part of the animal economy in the Ichthyosaurus, as in the most voracious of the existing fishes, consisted of a flattened tube, twisted into a spiral or corkscrew form, and reduced to the smallest possible dimensions.

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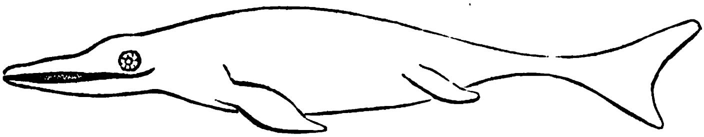
* Κοπρος (*copros*,) dung; λιθος (*lithos*,) a stone. There are strata, many square miles in extent, almost made up of these fossils.

Judging from the existing reptiles, and the gigantic sauroid fishes of the older period, it might perhaps have been anticipated that the marine saurians, of which the Ichthyosaurus is one of the most important genera, should be provided with hard bony plates, or *scutes*, as they are called, at once enclosing and defending the animal. The absence of such scutes among the fossils of the lias, which has not only retained and handed down all the hard parts in great abundance and perfection, but exhibits even some of the softer portions of the body, would alone render this questionable. But the doubt has been completely justified by the discovery of actual portions of the undefended skin, which, preserving the analogy with the cetaceans, appears to have been naked, of considerable thickness, and covered with minute folds and wrinkles on the belly, instead of scales.

Fig 64.



ICHTHYOSAURUS.
(Restored outline.)

On the whole, then, the Ichthyosaurus may be described as an air-breathing reptile, which sometimes attained a length of thirty to forty feet, which was covered like a whale with smooth, naked, thick skin, and whose place of ordinary habitation was the open sea. Its head was large and somewhat like that of the dolphin, but its general form, no less than the particular contrivances of the jaws and teeth, were truly crocodilian. Associated with this crocodilian head, we find enormous eagle-like eyes, carefully defended and made admirably efficient by an apparatus of bony scales, permitting distant vision in the air, near the surface of the water, and in the dim abysses of the ocean. The body of this creature was perfectly flexible and fish-like, but, instead of fins, it had two pair of very powerful paddles, permitting of the utmost freedom of motion in swimming, and forming not inconvenient limbs to assist in locomotion on land. A large and efficient vertical tail completed this strange mixture of fish, reptile, and whale, and, though no living representative exists not merely of its genus, but even of the great natural order to which it belongs, it once played no unimportant part in extensive tracts of ocean, which soon after the commencement of the secondary period covered that part of the northern hemisphere now occupied by the continent and islands of Europe.

Towards the close of the deposit of the great mass of red sandstone and marl which immediately rests on the palæozoic rocks, these beds seem to have gradually changed their character, the marl preponderating and becoming more calcareous. Although sandy and calcareous mud was still deposited uniformly, abundantly, and very widely, we have in the beds of mud thus preserved no distinct indications of the vicinity of land, for the fragments of wood that occur are almost invariably covered with marine animals, proving that they had floated or been drifted far out to sea. The change in the sea-bottom, and the lapse of time, accompanied by the upheaval or sinking of land, produced the effect of destroying many old species, while other new ones entered the field. These exhibited an undoubted approximation to the animals of a later period, and include some very curious star-fishes, several crustaceans, and a large number of mollusca or shell-fish, both bivalve and univalve, all having analogies with existing species, though all specifically different. Of these the most remarkable in their departure from the existing type are the Pentacrinite, the Terebratulæ among bivalve shells, and the ammonite and belemnite among the univalves. The fishes and the reptiles exhibit still more prominently the differences that then existed.

If we wish to pass in review the various groups most characteristic of this singular period, concerning whose natural history we have so many and such distinct facts recorded, we must imagine a wide tract of open sea, into which a quantity of fine sediment of calcareous mud was in some way carried and deposited.* From the distant land whence this mud was washed came also occasionally trunks of trees conveyed by marine or river currents. Attached to them, and also occasionally fastened to sea-weeds or other floating bodies, would appear in large clusters—(like the bunches of barnacles sometimes suspended from a ship's bottom)—the singular pentacrinites, their long stony column fringed thickly with branches of articulated stone, with a stony coat of mail surrounding the pouch or stomach, and a similar but more delicate defence covering the extensile proboscis. With innumerable arms widely extended in a complicated fringe, this strange mass of living stone expanded itself, and drew within its cold embrace the floating bodies on which it fed. One might fancy that some marine Briareus, looking on the strife and carnage of this great reptilian period, whose horrors might well have had the fabled effect attributed to the snakes of Medusa's head, had suddenly become petrified, retaining however its vital powers, and, with its complicated skeleton, continued to perform its office by cleansing the sea of an accumulation of decaying animal matter.

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* Such a deposit is probab'y now going on in the Yellow Sea, off the coast of China.

But while the Pentacrinite was thus the floating scavenger of that period, the bottom of the sea, although not covered with encrinites and corals, was well provided with other animals performing the same part in nature. The great beds of Gryphea—the oysters of their day—are sufficient proof of this, and the Terebratulæ and Spirifers tell the same tale. Among the invertebrate animals, however, the ammonite and the belemnite were undoubtedly the most remarkable, and, at least in certain districts of the sea, were enormously abundant. Some of them being enclosed in shells, some enclosing shells, and some perhaps not provided with any solid framework, swam about, or dwelt at various depths, and by their carnivorous and voracious habits greatly tended to keep down the exuberance of the lower forms of life.

The neighbourhood of the shore, and the shallow banks during this period were peopled by multitudes of fishes of moderate size, living chiefly on the crabs, lobsters, and shell-fish, or on the encrinital animals; and, for the purpose of crushing the shells of such creatures, these fishes were provided with a pavement of hard rough enamelled teeth fixed on the palate. The whole body also and the head were covered with plates of bone, also coated with enamel, and serving as a defence against the attack of the larger ammonites and belemnites. Farther out at sea, were tribes of sharks of different species, all predaceous and carnivorous, and many of them of the most gigantic proportions. No fishes like those now common on the coasts of England then existed on the earth.

The fishes, though abundant and represented by a powerful and important group, had ceased to be the lords of creation in the lias seas. The depths of the sea as well as the shallows, the broad expanse of waters as well as the coast-line, were in those days the dwelling-places of a group of reptiles of which every representative has long since become extinct.

Two of these have more especially attracted attention, in consequence of their great abundance in the fossil state in our own country, but they are by no means the only ones known. Of these two, one was more exclusively tenant of the deep, while the other was probably more frequently met with on the mud banks or on shore. Both were truly marine in their habits, and both seem to have served as the representatives of the great cetacean tribe—the whales, the porpoises, and other similar animals—now existing.

It is difficult to imagine, without appearing to caricature, the conditions of existence of such animals. We know indeed their form, their proportions, their strange contrivances of structure, their very skin, and the food which they devoured, and yet, knowing with absolute certainty these points, we hardly dare draw the conclusions which are suggested.

But I will venture to carry out the idea, and fill up in yet greater detail a sketch of the condition of the sea and its inhabitants during this portion of the reptilian epoch.

There were then perhaps existing on or near the land some of those reptiles which I shall describe in the next chapter; and with them were associated some true crocodilians, not much unlike the fresh-water garial inhabiting the Ganges. These, perhaps, might occasionally swim out to sea, and be found in the neighbouring shoals.

But these shoals were alive with myriads of invertebrated animals; and crowds of sharks hovered about, feeding upon the larger forms. There were also numerous other animals, belonging to those remarkable groups which I have attempted to describe in some detail. Imagine then one of these monstrous animals, a *Plesiosaurus*, some sixteen or twenty feet long, with a small wedge-shaped crocodilian head, a long arched serpent-like neck, a short compact body, provided with four large and powerful paddles, almost developed into hands; an animal not covered with brilliant scales, but with a black slimy skin. Imagine for a moment this creature slowly emerging from the muddy banks, and half walking, half creeping along, making its way towards the nearest water. Arrived at the water, we can understand from its structure that it was likely to exhibit greater energy. Unlike the crocodile tribe, however, in all its proportions, it must have been equally dissimilar in habit. Perhaps, instead of concealing itself in mud or among rushes, it would swim at once boldly and directly to the attack. Its enormous neck stretched out to its full length, and its tail acting as a rudder, the powerful and frequent strokes of its four large paddles would at once give it an impulse, sending it through the water at a very rapid rate. When within reach of its prey, we may almost fancy that we see it drawing back its long neck as it depressed its body in the water, until the strength of the muscular apparatus with which this neck was provided, and the great additional impetus given by the rapid advance of the animal, would combine to produce a stroke from the pointed head which few living animals could resist. The fishes, including perhaps even the sharks, the larger cuttle-fish, and innumerable inhabitants of the sea, would fall an easy prey to this monster.

But now let us see what goes on in the deeper abysses of the ocean, where a free space is given for the operations of that fiercely carnivorous marine reptile, the *Ichthyosau-*

rus. Prowling about at a great depth, where the reptilian structure of its lungs and the bony apparatus of the ribs would allow it to remain for a long time without coming to the air to breathe, we may fancy we see this strange animal, with its enormous eyes directed upwards, and glaring like globes of fire; its length is some thirty or forty feet, its head being six or eight feet long; and it has paddles and a tail like a shark; its whole energies are fixed on what is going on above, where the Plesiosaurus or some giant shark is seen devouring its prey. Suddenly, striking with its short but compact paddles, and, obtaining a powerful impetus by flapping its large tail, the monster darts through the water at a rate which the eye can scarcely follow towards the surface. The vast jaws, lined with formidable rows of teeth, soon open wide to their full extent; the object of attack is approached—is overtaken. With a motion quicker than thought the jaws are snapped together, and the work is done. The monster, becoming gorged, floats languidly near the surface, with a portion of the top of its head and its nostrils visible, like an island covered with black mud, above the water.

Such scenes as these must have been every day enacted during the many ages when the waters of the ocean were spread over what is now land in the eastern hemisphere, and when the land then adjacent provided the calcareous mud now forming the lias.

But a description of such scenes of horror and carnage, enacted at former periods of the earth's history, may perhaps induce some of my readers to question the wisdom that permitted, nay enacted them, and conclude rashly that they are opposed to the ideas we are encouraged to form of the goodness of that Being, the necessary action of whose laws, enforced on all living beings, gives rise to them. By no means, however, is this the case. These very results are perfectly compatible with the greatest wisdom and goodness, and, even according to our limited views of the course of nature, they may be shown not to involve any needless suffering. To us men, constituted as we are, and looking upon death as a punishment which must be endured, premature and violent destruction seems to involve unnecessary pain. But such is not the law of nature as it relates to animal life in general. The very exuberance and abundance of life is at once obtained and kept within proper bounds by this rapacity of some great tribes. A lingering death—a natural decay of those powers which alone enable the animal to enjoy life—would, on the contrary, be a most miserable arrangement for beings not endowed with reason, and not assisting each other. It would be cruelty, because it would involve great and hopeless suffering. Death by violence is to all unreasoning animals the easist death, for it is the most instantaneous; and therefore, no doubt, it has been ordained that throughout large classes there should be an almost indefinite rate of increase, accompanied by destruction rapid and complete in a corresponding degree, since in this way only the greatest amount of happiness is ensured, and the pain and misery of slow decay of the vital powers prevented. All nature, both living and extinct, abounds with facts proving the truth of this view; and it would be as unreasonable to doubt the wisdom and goodness of this arrangement, as it would be to call in question the mutual adaptation of each part in the great scheme of creation. No one who examines nature for himself, however superficially, can doubt the latter; and no one certainly, who duly considers the laws ordained for the general government of the world, can believe it possible for these laws to have acted without a system of compensation, according to which the vital energies of one tribe serve to prepare food for the development of higher powers in another.

CHAPTER IX.

THE GIGANTIC LAND REPTILES, THE FLYING REPTILES, AND OTHER ANIMALS CHARACTERISTIC OF THE OOLITIC AND WEALDEN FORMATIONS.

After the termination of that great deposit of calcereous mud, so characteristic of the older part of the middle secondary period, considerable change seems to have taken place in the relative position of land and sea; and, from the abundance of calcareous rock afterwards developed, as well as from the nature of the fossils, it may safely be concluded that these changes involved important alterations in the whole system of organic nature in this part of the world. Referring only to those districts which, being now land, enable us to discover their structure, and drawing our conclusions only from the actual facts that have been determined, we may venture to conclude, that immediately after the deposit of the lias, the bed of the sea was affected by widely acting earthquake movements, and that tracts of land, more or less extensive, rose up, especially on the north-eastern flank of the lias in Yorkshire, in several districts on the continent of Europe, and in the central and eastern portions of North America.

It also appears that these elevations must have alternated with depressions, and that thus a number of islands were formed in a sea of moderate depth, but frequently changing both in depth and in the nature of its deposits; the islands being the habitation of land animals, while the surrounding coasts afforded food and shelter for vast multitudes of fishes and other marine groups. The marine deposit, however, seems to have been nearly limited towards the west by a recently formed lias coast, leading us to suspect the existence of land extending westwards and northwards from the line of that bed. Possibly this land may have formed a broken ring surrounding a Mediterranean Sea, just as the two portions of the great continent of America, connected partly by the Isthmus of Darien, and partly by the chain of the West India islands, now enclose a tract under nearly similar conditions.

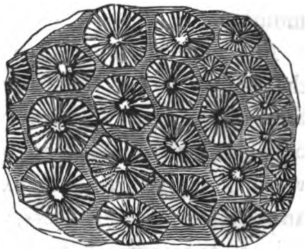
However this may be, the great eastern oolitic archipelago seems to have been limited towards the west by England, and perhaps terminated towards the north with the land which now forms the range of the Hartz mountains, the mountains of Saxony, and those of Bohemia. Throughout the whole tract the general conditions of deposit must have been nearly analogous; but there were many important modifications in detail, especially in the western, southern, and south-eastern part, where the older beds are most developed; while in the north-eastern and central districts, the newer beds are apparently the most important. The newest of all the deposits was a great fresh-water formation known as the Wealden group, occupying a portion of the south-east of England, and met with again in Hanover.

By a gradual change in the nature of the deposits, the whole oolitic range seems to have served as the habitation and burial-place of many successive races of beings; but there is nowhere evidence of such considerable or violent change as would justify us in separating the series into two or more parts. The whole was probably continuous; and, although affected by contemporaneous and successive disturbances frequently repeated, these hardly involved any changes of great moment modifying the general result.

The inhabitants of the sea during the oolitic period include, as might be expected, a vast multitude of species. Of these some were attached permanently to marine bodies, and so were partly or entirely dependant on a particular mechanical, chemical, or mineralogical, condition of the sea bottom; others were attached less permanently, possessing only imperfect powers of locomotion, and limited as to the depth at which they conveniently live; while there were others, again, swimming freely in the ocean, and limited only in their range by the nature of the supply of food. The first mentioned of these groups includes the coral animal and many others of low organization, the next comprehends the encrinites, star-fishes, sea-urchins, &c., as well as a number of crustaceans and insects, and a large proportion of the animals enclosed in shells; while the last, in some respects the most important and interesting group, includes the more highly organized mollusca, the fishes, and the marine reptiles. It will be convenient to describe, first, these different groups of the inhabitants of the ocean, and then proceed to the account of the land animals of the period.

The corals of the oolitic seas formed some considerable reefs and islands, especially during the middle part of the period; but the species then common resemble so closely those of existing seas in all important points of structure (fig. 65,) that it will not be necessary to describe them in detail. They differ, indeed, in specific, and often in generic character; but, in spite of this, there can be no doubt of the general analogy, and we find exactly the same set of contrivances

Fig. 65



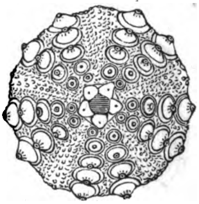
OOLITIC CORAL.
(*Astræa.*)

adopted to provide that varied and effectual resistance to the waves which characterizes the labours of the coral animal, and which are especially seen in those gigantic monuments of its labours distributed over a vast expanse of sea in the Tropics and the southern hemisphere.

The oolitic encrinites are neither more numerous nor more remarkable than those of an earlier period; and it would appear, indeed, as if the original form of the development of this tribe had by this time given way to a more advanced type. There are, however, still some, and those very pretty and interesting groups of these animals, amongst which we may enumerate a fossil well known to collectors in the west of England as the "pear" or "Bradford" Encrinite. This species grew from a large and swelling base attached to a rock or some marine substance; it was provided with a stout stem of moderate length, and the plates of the upper parts, or body, are singularly thick and strong. The rock immediately below a particular bed of clay (called the Bradford clay) seems to have been a favourite locality, since the remains are there found in great beauty. The stem, or stony column, terminated with five pairs of short arms rising immediately from the upper plates; and these, when expanded, collected food and conveyed it to the mouth.

Although the encrinites are not extremely abundant in the oolitic rocks, the tribe of radiated animals, to which they belong, was still amply represented. Star-fishes, sea-eggs, and sea-urchins of various kinds and size are universally distributed, and exceedingly beautiful species of an extinct genus (*Cidaris*,) provided with stout calcareous spines, are found singularly perfect (fig. 66.) It would hardly be thought possible, that animals provided, as these are, with a vast multitude of thick, heavy, and perfectly solid stony clubs, attached only to the shell at one point, should, notwithstanding, be perfectly free in all its movements, and, in fact, be greatly assisted in its locomotion by such appendages. The spines or clubs, to those accustomed only to watch the habits of animals inhabiting the land, and therefore surrounded with air and not water, appear so heavy as to be almost clumsy; but, in fact they are so little heavier than water, that they are perfectly manageable in that element, and when used as spades in the soft wet sand, the animal moves with great rapidity, and in any direction by their aid. Most of the animals of this group inhabit the shore, or moderate depths at no great distance from shore.

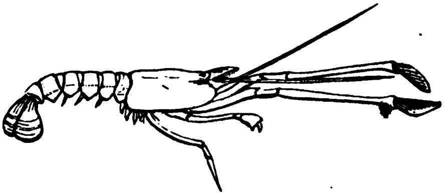
Fig. 66



Oolitic Sea-Egg.*
(*Cidaris.*)

The oolitic crustacea include an extensive series not very different from the lobster, the prawns (see fig. 67,) and the king-crabs of the existing seas. Most of these are found in one particular spot in the north of Bavaria, in a peculiar fine-grained absorbent stone, much used for lithographic purposes. This stone is calcareous; it has a peculiar as-

Fig. 67



Long-Clawed Oolitic Shrimp.
(*Megachirus.*)

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* In the specimen figured, the stony club-shaped spines are absent, as is often the case in fossils, but the small mammillated projections to which they were attached by sockets are very beautifully shown.

pect and a remarkably delicate texture, and has, doubtless, been deposited from an impalpable mud.

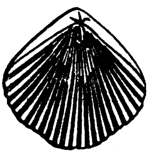
Fig. 68 *Fig.* 69

INSECTS OF THE SECONDARY EPOCH.

The numerous fossils it contains, and they are even more remarkable for their perfect condition than their number, include but few remains of ordinary mollusca, but on the other hand, a very unusual proportion of fishes, of crustaceans of various kinds, and of insects, often in the most singular state of preservation. From these as well as from other remains of insects and crustaceans of the same period, characteristic forms of which are given in the accompanying wood-cuts (68, 69,) we may deduce the fact that there was but little difference in general form, proportions, or structure between the ancient inhabitants of the sea-coast and the existing ones, so far as such groups are concerned, and that there is nothing in them to indicate a warmer climate, or any peculiarity in the condition of the atmosphere.

Among the shells most common during the oolitic period there are many whose resemblance to existing species is also striking, and which certainly point to a very different condition having then obtained; but the genus *Terebratula* seems to have been far more predominant than it now is, and in some localities particular species of these gregarious animals existed in beds at the bottom of the sea, almost to the exclusion of other animals.

Fig. 70

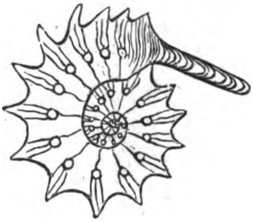


TEREBRATULA.

The tribes of bivalve and also of univalve molluscs were, however, amply represented during this period, and every day is adding to the number of species, and the variety of generic forms assumed by these creatures. From the careful study of these on the spot, much light will probably hereafter be thrown on the condition and depth of the sea, and the movements of the sea bottom during the part of the period of which certain groups are characteristic.

The *Ammonite*, so greatly developed in the lias seas, was scarcely less so during the whole of the succeeding period, and the variety of form which it exhibits is not less remarkable than the vast multitude of the individuals preserved. This form is sometimes more perfectly preserved also in the rocks of this period than in any others; and one example, in which the fragile termination of the aperture has been handed down in a perfect state, is given in the accompanying figure (fig. 71.) But this tribe of Cephalopoda was then represented by another group, numbers of which also are met with in the lias, and to which the name *Belemnite* has been applied; and this, taking the place of a more highly organized animal of its class than even the nautilus and ammonite, has been sometimes perfectly embalmed. The structure of the soft parts is indeed so beautifully shown in that same clayed bed from which the perfect ammonite has been worked out (the Oxford clay,) that the oolitic period is the most proper for its final description, though the animal has been already alluded to,* and is almost equally characteristic, not only of the lias and oolites, but also of the newer secondary deposits.

Fig. 71



OOLITIC AMMONITE.

The Belemnite has received its name from a peculiar

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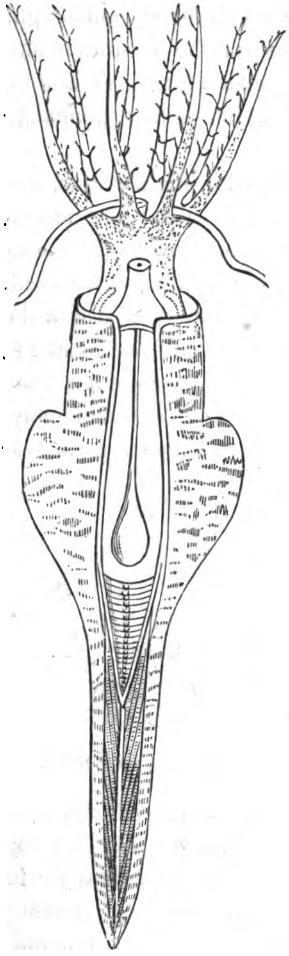
* See *ante*, p. 148 *et seq.*

Fig. 72



Belemnite.
(Restored Figure.)

dart-shaped stony fossil which is not uncommon, and which, under various local names, (such as thunderbolt, devil's toe-nail, &c.,) is familiar to most people in the different parts of England where it occurs abundantly. It is found varying in size from specimens not an inch long, to others measuring upwards of a foot; but the structure is generally seen to be the same, the fossil when complete being more or less cylindrical, with one conical extremity, the other end widening out and exhibiting a conical hollow, which is sometimes filled up with a number of little cup-shaped bodies like watch-glasses, fitting into one another.

Without amusing the reader with the mistakes of different authors with regard to this fossil, it will be sufficient to state at once what it is, and what is the meaning and use of the various parts, since the whole history of the animal is now perfectly cleared up by the aid of specimens which not only exhibit all the solid parts in their natural position, but even present to our notice the muscular fibre, very little altered.

The whole contour of the animal is indeed accurately determined, including the feelers projecting from the head, the fins, the tail, and even a solidified dark fluid once preserved within the body, and intended to serve the living animal as a defence from its enemies by enabling it to cloud the surrounding water when attacked or desirous of concealment.

The fossil known to Geologists by the name *Belemnite* is the internal skeleton of a cephalöpodous animal very much like the cuttle-fish, but provided not only with a solid framework for the attachment of muscles, but also with an apparatus like that possessed by the nautilus and ammonite. The animal, appears, however, to have combined also in some degree the characteristic peculiarities of several of the more highly organized genera of cephalopods, and perhaps was fitted for a condition of the sea in which the enemies of such an animal were more numerous and powerful, and its food less easily obtained, than is the case at present.

It is now known that the animal of the Belemnite was naked, or rather that it was enclosed within a muscular sheath, which formed a closed sac or bag terminating above with the head. From around this eight arms proceeded, whose length in the species examined seems to be about one-fourth part of the entire length of the animal; and each arm was provided with from fifteen to twenty pair of hooks resembling those now seen only in the most powerful and the fiercest of the whole tribe of Cephalopoda, and used to pierce the flesh of fishes and other animals, in order to secure firm hold when the Belemnite was about to seize its prey.

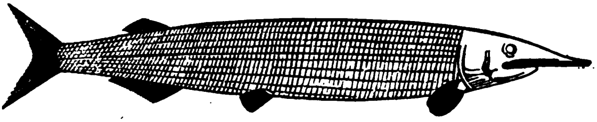
The head was provided with very large eyes: the jaws were probably horny: and, besides the eight arms, there seems to have been one pair of long tentacles. Far down below the head, and within the cavity of the shell, there was placed an oval sac containing black fluid, communicating by a tube with the aperture. This fluid exactly resembles the ink of the common squid; and there can be no doubt that it was used by the animal in the same way, and for the same purpose, namely, to darken the water when its possessor, becoming alarmed, desired to escape. The ink itself in a solid state, the bag which contained it, and the tube or pen by which it was shot out into the water, are all preserved in some of the specimens of this fossil.

The mantle of the Belemnite, passing over the guard or shell, seems to have accommodated itself to the shape of the shell, and terminated in a blunt point. Two fins, however, of a rounded form, and of considerable size, extended on each side near the middle of the animal. From this position of the fins, from the shape of the shell, and from its general structure, it has been concluded that the animal commonly remained in a vertical position, rising and sinking with great facility, and possessing very unusual powers of locomotion and destruction.

The larger belemnites, as well as the ammonites of this period, must have attained very gigantic dimensions compared with their subsequent or previous size, and compared with the ordinary inhabitants of the sea. Few fishes, perhaps, could have escaped them except the larger sharks; and even the young ichthyosaurs, plesiosaurs, and other reptiles, may have fallen a prey to these rapacious and terrible monsters.

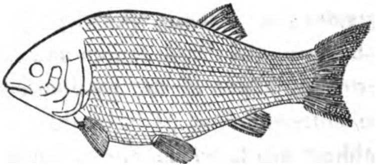
Fishes of various kinds were manifestly very abundant during the period we are now considering; but, except the shark tribe, we have no knowledge of the existence of any of large size. Those of which the remains are most common were enclosed in enamelled plates or scales of considerable proportionate size, and they possessed powerful teeth, enabling them to prey on the Crustacea and on each other, as well perhaps as on the stony Radiata. Another group of fishes provided with sharp conical teeth, and belonging to the sauroid family, were mostly small, but include some interesting species with very long snouts (see fig. 73.) These, no doubt, were rapid swimmers, while the former were probably slow and heavy in their movements. One of the more common forms of the latter is represented in outline in figure 74.

Fig. 73



Aspidorhynchus.

Fig. 74



Lepidotus.

Reptiles abounded throughout this period, and exhibit many forms no less interesting than they are remarkable. Many of them seem to have been more or less exclusively marine in their habits, but many others were partly, and some entirely, terrestrial; these latter exhibiting peculiarities of structure which render them well worthy of minute description.

The reptiles of the oolites include one genus strictly marine in addition to the Ichthyosaurus and Plesiosaurus; and there were also several animals of the same tribe whose habits were aquatic, although, from peculiarities of structure, they are referred to the crocodilian group. These chiefly resemble the crocodile or garial of the Ganges, a species especially organized for the capture of fish. There are also several others exhibiting analogies with existing crocodilian reptiles. I shall not, however, dwell on the slight differences of structure by which this group is characterized, but, after saying a few words concerning the third true marine reptile, and a gigantic whale-like reptile called *Cetiosaurus*,* proceed at once to some species still more gigantic in comparison, which at the same period inhabited the land.

Associated with the remains of the long-necked plesiosaur there are found in some of the clay beds of the oolites the teeth and bones of several species of animals very nearly allied to that genus in many important characters, but of enormously greater size. These species seem to have been intermediate between the Plesiosaurus and Ichthyosaurus, the teeth, vertebræ, bones of the extremities, &c., being more like the corresponding parts of the former, but the animal resembling the latter in the absence of apparent neck. For these reasons the genus has been named *Pliosaurus*.†

One of the most remarkable of the numerous crocodilian reptiles,—a natural group, which, though not first introduced into the earth in the middle secondary period, yet seems then to have attained in all respects its chief developoment,—was the *Cetiosaurus*, already alluded to. This animal, rivalling the largest whales in bulk, seems to have been of strictly aquatic, and most probably of marine habits, and was indeed closely allied to the group of true marine reptiles. In this genus, too, was combined a broad vertical tail and extremities developed into webbed feet, the toes of which were terminated by strong claws, probably assisting the animal in taking its prey. Nothing is known of the teeth or skull, but there is no doubt that the habits of the genus must have been strictly predaceous.

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* Κητος (*cetos*,) a whale; σαυρος (*sauros*,) a lizard or saurian.

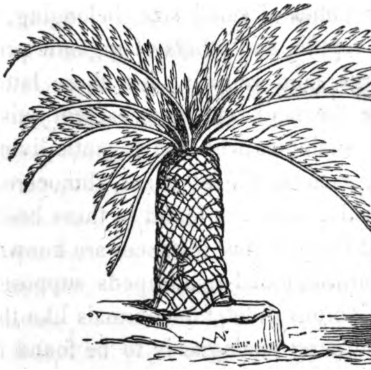
† Πλέιων (*pleiōn*,) more; σαυρος (*sauros*,) a saurian: having greater analogy with reptiles than the plesiosaurs.

About the middle, or perhaps before the middle of the secondary period, there existed a considerable tract of dry land, so near what is now England that the remains of the animals dwelling there could be deposited at the bottom of the sea, and this in a condition admitting of their being almost instantly embedded and preserved. One bed in particular of the oolitic series, occurring at Stonesfield, near Oxford, has received remains of this kind in comparative abundance; and we find in it, associated with marine shells, several fruits, leaves, and other fragments of vegetable origin, several wing-cases and other parts of beetles and flies, some very singular bones of small size, belonging, it would seem, to a flying reptile, and others of gigantic proportions, referred to large land reptiles; but these latter were exceedingly unlike the land reptiles at present existing, and exhibit curious analogies with the gigantic living pachydermal mammals, such as the elephant, rhinoceros, and hippopotamus. Lastly, there are found in these beds, though so rarely that but three or four instances are known, the remains of small warm-blooded quadrupeds supposed to be referable to insectivorous didelphine animals like the opossum, whose nearest living analogue is to be found in America and the Australian continent.

Let us first consider briefly the climate and terrestrial flora indicated by the organic remains, as far as the plants will enable us to judge.

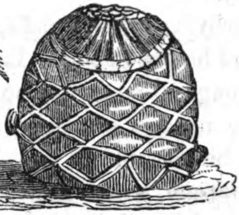
The first thing that strikes us with regard to these fossils is that they belong almost entirely to the family of CYCADEÆ, none of which are now indigenous in Europe, although they are found in abundance in sub-tropical and south temperate latitudes. They resemble the palms in many respects, but also possess analogies with the large and important group of *Coniferæ*, while they imitate the ferns in the mode in which the leaves are curved up at their extremities, and partly in the leaves themselves. Of the whole group, the *Cycas* and *Zamia* are considered to be those offering the nearest resemblances to the extinct species. The former, the Cycas, of which a South African species is represented in fig. 75, exhibits a crown of foliage at the summit of a simple cylindrical trunk of considerable height which has no true bark, but is surrounded by scales originally the bases of leaves; the latter is generally shorter, and the mass of woody matter whence the leaves rise is less decidedly a trunk. So far as we can judge from the remains found fossil (see fig. 76,) the climate was probably warmer during the oolitic period than at present, but it certainly differed in many respects, and possibly more resembled that of New Zealand than of England.

Fig. 75



RECENT CYCAS.

Fig. 76

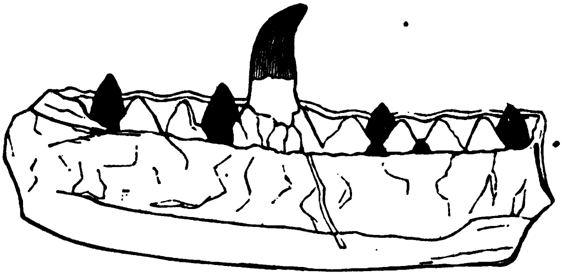


CYCADEOIDEA.

The land reptiles, detached fragments of which are all that remain to assist us in re-peopling the ancient shores thus clothed with cycadeous vegetation, were of sufficient magnitude and importance in the scale of creation to require, in all probability, numerous companions on the earth, although few of their remains have yet been laid bare. One of the genera has received the name *Megalosaurus** from its gigantic size, although the size is, in some respects, the character of least importance.

The jaw, or rather the fragment of a jaw with teeth (fig. 77,) a few vertebræ, and some of the bones of the extremities, form the scanty amount of material for the description of this animal; but these remains are enough to enable the comparative anatomist to decide with certainty with regard to several most important characters, and they suggest inquiries and probable conditions of the skeleton, of which the correctness may be tested by future discoveries.

Fig. 77



Megalosaurus.
Portion of the Lower Jaw.

The tribe of lizards, one of the most important of the existing reptilian groups, forms a link in the chain by which the animal now under discussion was connected with known forms; but, although analogies unquestionably exist between the lizard and the Megalosaurus, and also between this animal and the crocodiles, there yet remain marked and peculiar characters separating it from both. It is now considered as one of an extinct family, super-eminently remarkable for the great height at which all the species stood above the ground in proportion to all other reptiles; and the height is indicated not less by the actual size of the bones of the extremities, than by the provision made in the skeleton to resist the pressure of an enormous weight.

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* Μεγας (*megas*,) great; σαυρος (*sauros*,) a lizard.

The Megalosaurus was a gigantic carnivorous land reptile, its body being of enormous size. In all probability it was not, like the crocodile, clothed in scaly armour, but it stood with its whole body considerably above the ground, in bulk and general appearance rather resembling the hippopotamus than the gigantic alligators of the present day. It was most likely provided with a true reptilian tail, whose length was considerable, although not nearly so great in proportion as that of existing crocodiles and alligators.

The form of the fragment of the jaw which has been preserved (fig. 77) marks in some measure the shape of the head, showing that it was terminated by a straight, narrow, and long snout, not tapering, but compressed laterally. The teeth were of moderate size. They formed, however, strong and powerful cutting instruments, for the fore part was sharp and jagged, and the hind part much thicker and blunt, while ample provision was made for a constant succession during the whole lifetime of the animal.

The vertebræ are somewhat peculiar in form, and present nearly flat surfaces to one another; but it is chiefly one group, consisting of five, firmly cemented together into a solid mass, and distributing the weight of the body upon the hinder extremities, that forms an exception to the ordinary reptilian character. Except the megalosaur, and the two or three extinct species now grouped with it, and belonging to the same period, no reptile has more than two bones cemented together for this purpose; and this is found sufficient, because much of the weight is supported directly upon the ground either by the body or tail of the animal. On the other hand, all the heavy land quadrupeds exhibit great strength and solidity in this part. It is interesting to find the long and powerful extremities of this monstrous reptile of the Oolites thus combined with a structure altogether different from that of other reptiles, but manifestly related to its habits. The vertebræ of the Megalosaurus thus united are not in a straight line, but describe a gentle curve with the concavity downwards.

The bones of the extremities are long, large, and hollow, resembling in this the corresponding bones of land quadrupeds. They exhibit, however, a mixture of the characters observed in the crocodile and in some lizards. They are so large, compared with the bones of animals most nearly allied, that, if the same proportions had held throughout, the Megalosaurus might be compared with a crocodile of sixty or seventy feet long, did such a monster exist; but the whole structure of the animal indicates considerably greater bulk and height in proportion to length than is seen in other reptiles. The real length was probably about thirty feet, the trunk being broad and deep, the tail comparatively short, and the limbs unusually long. We have no means of deciding in what manner the tail was carried.

The gigantic land reptile of the oolites was accompanied by another, and still more oddly constituted animal, connecting the reptiles with birds in a manner not less remarkable than that by which the megalosaur unites them with quadrupeds. The animal is called *Pterodactyl*,* and is a true flying reptile (fig. 78.) It exhibits, however, in the various parts of its skeleton such strange resemblances to

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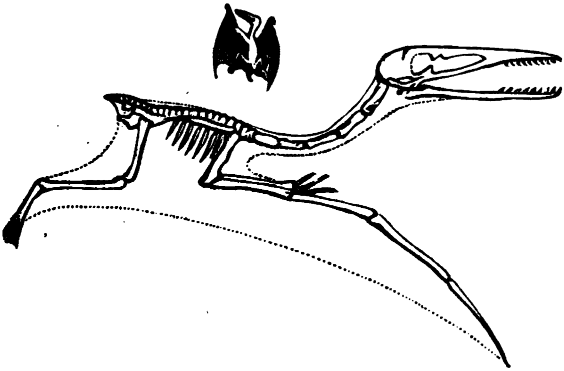
* Πτερον (*pteron*,) a wing; δακτυλος (*dactylus*,) a finger: from its mode of flight.

Fig. 78



Pterodactyl.

other and very widely separated groups, that it was successively described as a bird and a bat, before it was acknowledged according to its true analogies; and this not without some ground, since the mistake arose from the presence of peculiarities of structure considered in each case as characteristic of the two great classes of Vertebrata to which it was referred. It is, perhaps, the most extraordinary of all the beings of whose former existence the study of fossils has made us aware, and is that which if living would appear most unlike any thing that exists in the known world.

In the external form of the body the Pterodactyl probably resemble the bats or vampires; and some of the species attain the size of a cormorant, although others were not larger than a snipe. The resemblance, however, to the bat tribe, was limited to the form of the body, for the head was totally different, the snout being enormously elongated, and the eyes exceedingly large; while the organs of flight or wings were even more powerful in proportion, and the legs were probably capable of being used in the water, assisting the animal to swim. The neck, also, was long, and like that of a bird. Let us now consider a little more in detail some of the peculiarities of structure of this strange monster.

In the first place, the skull, far from resembling that of a bat or bird, resembles in its general proportions, and even in some points of detail, that of the crocodiles; and the reptilian analogies are completely preserved in the position and small size of the cranium, and in the enormous prolongation of the snout. The lower jaw is not less reptilian, and is provided, as well as the upper jaw, with a long row of powerful teeth implanted in sockets, and successively replaced as they were worn and lost. The number of these teeth was about sixty; they are conical like those of the crocodile, but larger compared with the size of the jaw. The whole of the proportions of the head indicate a creature of great strength, capable either of darting down upon fishes or preying upon the smaller land animals.

The neck of the Pterodactyl, although it contains only the usual number of vertebræ (seven,) must have been of great length, and well fitted to support and move the powerful head just described; but an unusual provision is observable in the neck, assisting to give additional strength to the head, a set of bony tendons running along the vertebræ for this purpose. The length of the neck corresponds with what we see in birds, and indicates a perfect adaptation of the animal for rapid and long-continued flight. In one specimen the head is thrown back so far, that the base of the skull almost touches the tail, without the bones appearing to be in an unnatural position.

The number of vertebral bones in the back is very considerable, and nearly three times that of birds. In this respect, and in the thread-like form of the ribs, so unlike the broad and flat plates of bone exhibited in birds, the analogies are with the lizard tribe; but, on the other hand, the tail possesses only twelve or thirteen vertebræ, and so far is bird-like.

But it is chiefly in the bones of the extremity, by means of which the animal was enabled to fly, at the same time retaining the power of walking and in all probability of swimming, that we find the most singular of the mechanical contrivances, and observe a structure different from that of any other species, either living or extinct.

The bones which support the wings of a bird exhibit, in spite of great external difference, a good deal of similarity to the bones of the fore extremities of quadrupeds, and even reptiles; and it might have been expected, that, in adapting a species of either of these latter classes for flight, and enabling it to live chiefly in the air, similar modifications would have been adhered to. But the fact is not so. The wings of a bird owe a great part of their efficacy to the feathers with which they are covered; and as it did not enter into the plan of nature to provide quadrupeds or reptiles with these appendages, other mechanical contrivances are resorted to by which the power of flight is obtained, and the common integument preserved in the bat and Pterodactyl.

In bats, which are flying quadrupeds, this modification consists in the extraordinary development of all the fingers, upon which skin is stretched like the silk on the rods of an umbrella; and this skin extends not merely between the elongated fingers, but also from the last finger to the legs and feet, and so to the tail. The thumb is partially left free, and serves as a hook by which the animal suspends itself; but the toes are exposed, and are moderately long.

There is no really flying reptile now existing, but in one species (the *Draco volans*,) which is able to support itself for a short time in the air, there is a very imperfect flying apparatus, which chiefly acts as a parachute, supporting the animal in its long leaps. This consists of an expansion of the skin over a series of false ribs extending horizontally from the back bone.

In the Pterodactyl, however, which is evidently and expressly contrived for flight, a very singular contrivance is introduced, and it is one which seems to have ensured to the animal the power of walking and swimming, as well as flying (see fig. 78.)

In order to effect this, the bones of the fore extremity, so far as regards the shoulder and arm-bones, the wrist and the hand, scarcely differ from the ordinary proportions of those bones in lizards, and correspond with the dimensions of the hinder extremity, so that up to this point there is no peculiar adaptation for flying. On examining the bones of the fingers, however, we find that the number of joints in that which corresponds to the little finger is increased to five, and each joint is enormously lengthened. To the whole of the little finger, thus produced till it has become longer than the body and neck together, a membranous wing was attached, which was also fastened to the rest of the arm, to the body, and to a portion of the hinder extremity. When, therefore, the arm was extended, the wing was not necessarily expanded, and only became so on the little finger being also stretched out so as to be at right angles to the arm; and the membrane was then nearly surrounded on four sides by bone. By this contrivance the necessity of employing the whole arm in the mechanism of flying as in the bird, or the whole hand as in the bat, was done away with, and the flying apparatus being confined to one finger, the arms and hands could be readily and conveniently made use of like the corresponding extremities of other animals.

The great peculiarity, then, in the Pterodactyl, with regard to the organs of locomotion, is the freedom with which the arms and legs could act when the wings were not in use—and this extends even to the structure of the toes, which in the bat form only a single hook, but in the Pterodactyl were free, and would allow the animal to stand firmly on the ground, to walk about like a bird, to perch on a tree, to climb rocks and cliffs, and possibly also to swim in the ocean.

We have, therefore, in this singular genus an animal which, in all points of bony structure, from the teeth to the extremity of the nails, presents the characteristics of a reptile, being even perhaps covered with scaly armour, and which was also a true reptile in the important peculiarities of the structure of the heart and circulating organs. But it was at the same time provided with the means of flying; its wings, when not in use, might be folded back like those of a bird; and it could suspend itself, by claws attached to the fingers, from the branches of a tree. Its usual position, when not in motion or suspended, would probably be standing on its hind feet, with its neck set up and curved backwards, lest the weight of the enormous head should disturb the equilibrium of the animal.

The remains of quadrupeds found associated with these anomalous and long extinct forms of reptiles, are hardly sufficiently perfect to enable us to determine except very generally the kind of animals to which they belonged, but they do not seem to present any wide deviations from the existing type. They appear to be marsupial in character, and to resemble most the tribe of opossums,* a fact no doubt sufficiently curious, but hardly affording evidence enough on which to base any speculations concerning the nature or extent of the land, or the possibility of other quadrupedal associates. The animals in question were no doubt insectivorous; and, as the remains of insects have been frequently obtained from the same beds, this is a point of some interest. It was certainly the case that a group of animals, the undoubted representatives of the highest class of created beings, was introduced into the world before or during this oolitic period, and it would be strange if such group, having been introduced, remained unimportant or actually disappeared. But judging only from the negative evidence before us, something of this kind must be assumed, since there is subsequently frequent and distinct proof of the near presence of land, without any mammalian remains. It should not be forgotten, indeed, that of all animal remains, those of small quadrupeds inhabiting islands in a wide ocean, are the most likely to be lost, and that, in a case like this, negative evidence is really of very little value.

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* The use of the pouch, the characteristic peculiarity of structure in marsupials, may possibly be connected with the condition of the land which animals so provided usually inhabit. There is reason to suppose, for instance, that a great part of Australia, where such animals are now chiefly

The bones of true birds have not yet been found in any formation older than the chalk, but we have already seen that there is good reason to believe in the existence of such animals at least as early as the new red sandstone, the footmarks in beds of that age both in America and England affording evidence to this effect. Now, if birds existed

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found, is remarkably exposed to drought, and that there are in that country large tracts deprived of rivers and lakes, and in which comparatively few springs of water exist in the interior. The animals being thus obliged to carry their young for long distances to obtain the necessaries of life—food and water—need the singular provision accorded them for this purpose. This view is not inconsistent with the presence of gigantic reptiles inhabiting the land near the sea-coast, although no such reptiles exist at present in Australia.

during the new red sandstone period, it is most likely that they also were continued from that time without interruption. With regard to this subject, it must, however, be acknowledged as one on which it is easy to speculate, but on which speculations are nearly useless.

There is nothing in the distribution of the fossils which entitles us to assume the total completion of one series of operations, and the commencement of another, between the deposit of any of the oolitic beds, commonly so called; nor does it appear that any great and sudden changes took place, at least till after the termination of the Wealden deposits. The latter present to our notice some additional and remarkable species of animal remains; but this is not astonishing, since the beds are extensive and of fresh-water instead of marine origin. On the other hand, many species are continued into the Wealden beds from the oolites; and some pass through that series, their remains appearing again in the newer sandy beds at the commencement of the cretaceous period. The local deposit called "Wealden," as it is seen in the south-east of our island, possesses great interest, arising from the presence of a series of fresh-water fossilliferous beds, chiefly of sand with imperfect bands of shelly limestone, terminated by a thick deposit of clay. The main interest arises from the fact that these were probably formed in an estuary, or at the mouth of some great river, and therefore in the immediate vicinity of a tract of land. Fresh-water shells and crustaceans, together with land plants, insects, &c., are here associated with fishes, which may, indeed, have lived in an estuary, but which present no distinct mark of fresh-water origin. Here, once more, we meet with land reptiles associated with aquatic crocodilian genera; and some of these land reptiles, like those of the older period, exhibit a remarkable resemblance to the pachydermal quadrupeds, extending, indeed, in this case to the possession of distinctly herbivorous habits. These species, again, are not alone—they are associated with the very same gigantic carnivorous land reptiles met with in the oolites, and the singular flying reptiles already described; but, although the quarries have been diligently searched, and the evidence carefully collected, there has not hitherto been obtained distinct proof of the presence of birds, and there is no trace, not even the slightest, of any true quadruped.

The gigantic companion of the megalosaur, during the Wealden period, has received the name of *Iguanodon.** It is known to us by the teeth and a considerable part of the skeleton; but, unfortunately, there has not yet been found any portion of the skull sufficiently perfect to be absolutely identified with the other bones.

The teeth of the Iguanodon (79, 80, 81) are partly composed of bone, gradually becoming softer from the edge inwards, and partly of enamel, by which they are surrounded; the result of this contrivance being the formation of a

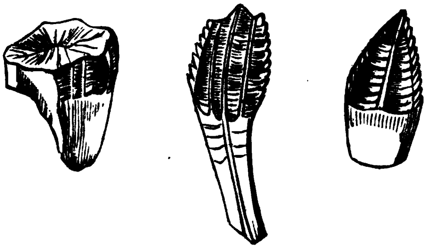
Fig. 79 *Fig.* 80 *Fig.* 81

IGUANODON.
Teeth in different Stages of Growth.

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* *Iguana* a recent West Indian lizard; ὀδοὺς (*odous*,) a tooth: from the resemblance of the teeth to those of the iguana.

slant surface of the crown of the tooth, and therefore of a sharp cutting edge. While young, the tooth presents a sharp cutting edge, and is lancet-shaped (81:) as it grows further out from the jaw, it assumes the form seen in fig. 80, and is then a powerful instrument, well adapted to separate tough vegetable fibres; while in its most advanced state (79) it ceases to be adapted to this purpose, but is strong and flat, and at the same time uneven, the pulp of the tooth projecting from the surface, which is worn so as to be nearly horizontal, and forming a transverse ridge. The teeth therefore begin by being incisors, and in the course of time, as they become worn, they pass into the condition of grinders,—a curious change, providing for the animal a perpetual supply of teeth of all kinds, some enabling it to nip off tough vegetable food, and others helping to grind that food properly before it is committed to the stomach.

The vertebral column of the Inguanodon is on a scale commensurate with the vast bulk of the animal. The vertebræ themselves have nearly flat surfaces, and are large and somewhat wedge-shaped, exhibiting rather crocodilian than lacertian analogies, although essentially different from both those types of structure. The neck is not known, since no vertebræ have yet been found belonging to this part. The sacrum, or that part of the back-bone, cemented together to distribute the weight of the body on the hinder extremities, includes five vertebræ, as in the megalosaur; and in one specimen this continuous solid ridge of bone measures seventeen inches in length, and its breadth, though only eight inches at the fore part, becomes as much as thirteen inches towards the hinder part. The magnitude, both in diameter and length, of the thigh and leg-bones, corresponds well with the large portion of the spine thus grasped, as it were, by the bones of the pelvis, and strongly points to the terrestrial habits of the animal. The total length of the extremities seems, in some cases, to have exceeded eight or even nine feet, and the bones of the foot are gigantic even beyond the proportions thus indicated, since one of the separate bones measures thirty inches in length, and the last joint of the toe, to which a claw was attached, is five inches and a half long. There was thus an ample base for the vast column supporting the body.

The tail of the Iguanodon was probably very much shorter in proportion than that of crocodiles, and was very dissimilar. It must, notwithstanding, have been large, and flattened laterally, being of considerable breadth in the vertical direction near its attachment to the body. The ribs were unusually large, broad, stout, and long, forming a strong case for the huge abdomen. They also extended very far forwards.

The general dimensions of the Iguanodon, though undoubtedly very enormous, have often been greatly exaggerated, since it has been assumed, that, in order to arrive at these dimensions, it was only necessary to compare the proportions of any part with those of the corresponding part in the species supposed to be most nearly allied. The proportions in this genus, however, must have been very different from those of lizards and crocodiles; and, while the bones of the extremities were perhaps six or eight times larger than those of the most gigantic alligator, the whole length of the Iguanodon is not likely to have exceeded thirty feet. Even then, however, allowing about three feet for the head, and assuming that the neck was short, and that the tail was about thirteen feet long, which it is calculated would be the extreme size, we still have a length of twelve feet for the body, and this is much more than is seen in the trunk of any living animal. The body being of this length, and perhaps of more than corresponding bulk, and lifted many feet from the ground, reaching perhaps to the height of twelve or fifteen feet,* must indeed have been sufficiently monstrous, and departed widely enough from any known animal to justify the accounts that have been given of its strange and marvellous proportions.

The *Hylæosaurus*† was another land reptile supported on long legs, and of massive proportions; but it differed in some important characters from the Iguanodon, and by no means attained such large dimensions. A considerable part of the skeleton of this animal has been found, and is preserved in the British Museum, but, unfortunately, these fragments do not include either the skull or teeth, or, indeed, any thing that can indicate the manner of arrangement of the teeth in the jaw, although it is probable, from other parts of the body, that they approximated in this point to the lizard type. The animal was probably about fifteen feet long, and of a height proportioned to that of the megalosaur. It was covered with a scaly armour, the plates being oval or circular, and therefore not fitting one another, but studded in unconnected order over the surface of a tough skin. It has been supposed by Dr. Mantell, that certain broad bones found with the skeleton formed a fringe on the back of the animal, but Professor Owen has suggested that they may, with greater probability, be ribs which defended the abdomen, analogous to a corresponding contrivance in the Ornithorhynchus.

Reverting now to the *Megalosaurus*, which, in some of the important characters I have referred to, is nearly allied to the *Iguanodon* and *Hylæosaurus*, it appears that these three form a natural and well-marked group of reptiles now entirely extinct, combining a complicated method of implanting the teeth in sockets, with limbs of gigantic size and strength, sustaining a bulky trunk by a long arched sacrum firmly cemented into a bony ridge. These modifications of structure, the most perfect yet discovered in reptiles, are found in animals which attained colossal dimensions, and must have played a conspicuous part during the middle secondary period, as well in the character of carnivorous as herbivorous animals. They seem, indeed, to have been the most important members this earth has ever witnessed of that great natural class of cold-blooded oviparous animals which we call reptiles.*

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* The tallest living elephant rarely if ever attains the height of eleven feet. Out of eleven hundred, from which the tallest were selected and measured with care on one occasion in India, there was not one that equalled eleven feet.

† Υλαιος (*hylæos*,) a wood; σαυρος (*sauros*,) a reptile. The reptile of the woods or wolds of Kent and Sussex.

And these animals were by no means rare during their period of existence, for, with regard to the Iguanodon alone, fragments of not less than seventy individuals appear to have come under the inspection of one person (Dr. Mantell) within a few years, all of them having been extracted from a few quarries of Tilgate grit, opened for road-making and for the supply of rough stone for building purposes. There is no reason to suppose that the species in question was confined to this locality, or was more abundant there than elsewhere, nor that it was limited to the Wealden district as exhibited in the south-east of England, where, it must be remembered, the strata have a vertical thickness of not less than a thousand feet.

It is, no doubt, difficult to confine the imagination within due bounds when we endeavour to recall scenes enacted during the earlier periods of the earth's history, and to picture these past events without running into extravagance, and without overstepping the limits of simplicity and probability, which should always characterize natural history.

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* Owen's "Report," *ante cit.* p. 195.

I will, however, notwithstanding the difficulty and danger, venture now, in concluding this chapter, to shadow out to the reader a few descriptive scenes, which may serve to give a better definition to the views he may have derived of the remarkable geological epoch described in the present chapter.

I think there is no doubt that we ought to regard the whole of the oolitic series from the lias to the chalk as one distinct period involving many great changes, but still well marked throughout by its own group of vegetables and animals successively developed or successively introduced. Taking this view, we may recognise in the vast variety of created beings thus grouped together, one unbroken series, affected from time to time by local circumstances and conditions; and I venture, therefore, to picture the various members of this series, without special reference to those beds in which they seem to us now to be most abundant, because I doubt whether in many cases we are at all able to decide upon such a point for want of evidence. The time during which the oolitic period lasted was, however, sufficient for the destruction of many species, and the introduction of an equal or greater number of new ones; and I only question the fact of any sudden or considerable change of this kind being distinctly indicated by the fossils of any known locality.

The great deposit of calcareous mud, which has been described under the name of lias, and which is so richly loaded with interesting fossils, does not pass by any sudden change into more calcareous beds, and so into limestone, but first of all seems to have become more sandy. The sand is often loose and micaceous, and it probably assisted, by forming a sea-bottom so entirely different from the lias, to change the inhabitants of that sea-bottom, and produce the necessity for the introduction of a distinct group. This is the more probable, since we find that the free swimming animals, such as the belemnites, were little or not at all altered, while the upper lias sands contain but few fossils of attached animals, and these afterwards give way to oolitic species.

The first change, therefore, announcing the introduction of the oolitic period may have been a depression of the coast line of the liassic sea, altering the conditions of life by changing at once the depth and the nature of the sea-bottom, and permitting a deposit of sand to cover the clays of the lias as yet imperfectly hardened, and form a basis for the great deposit of limestone about to be super-imposed. As we know, from the position of the lias with respect to the underlying red sandstone, that land probably extended not only to the west of England, and therefore into the present Atlantic Ocean, but also in various parts of modern Europe, we may understand that there may have been many islands in the intermediate sea, even if the depression in one part was not accompanied by corresponding elevation in another.

However this may have been, the lias sea-bottom was succeeded, as we have said, first by a sandy, and then by a calcareous bottom, and the inhabitants were modified accordingly. Soon a deposit of nearly pure carbonate of lime was formed under circumstances which allowed it to collect round minute organic particles, and form the peculiar stone we designate *oolite;* and this deposit was repeated, not incessantly but at intervals, during the whole of the rest of the period of the marine deposits. The conditions being favourable for the existence of such animals as shell-fish, these were developed abundantly, and for a long time their dead and broken shells accumulated, forming at length complete and thick bands of shelly matter, which afterwards hardening became shelly limestone. The seas at this time abounded with fish, amongst which were many species adapted to feed on mollusca, crabs, and lobsters, most of them being of small size, but provided with solid plates of enamel on the palate, enabling them to crush the hard shells of the animals on which they fed. In the older beds little coral appeared, and we find few remains of large animals, either fishes or reptiles. For a long time, allowing of the deposit of near three hundred feet of strata in great part fossiliferous, and almost uniform in character over a considerable extent of country, there were no important changes, but the evidence that we at present possess, although imperfect, renders it not unlikely that depression might be going on at intervals.

At length, however, and still in the early stage of the deposit of the oolitic rocks, a bed of clay appears partially covering the calcareous deposits in the south and west of England; and contemporaneously in other districts appears the "Stonesfield slate," a fissile limestone already alluded to, occurring near Oxford, a somewhat similar slaty rag at Colley Weston, in Northamptonshire, and some gritty and shaly beds in the north of England, well seen on the coast of Yorkshire, near Scarborough, while there were also other beds occurring still further to the north at Brora, in Sutherlandshire. The evidences of adjacent land are here not to be questioned, and we have now to consider what may have been the nature and condition of this land, and its relation to the deposits preceding and succeeding the date of its formation.

It is, on the whole, not unlikely that partial elevation of the sea-bottom was in some way connected with the interesting set of phenomena now under discussion. The bed of clay first mentioned rests on the oolitic rock; and at the junction of the two there are vast multitudes of the remains of the *Apiocrinite*, a pretty encrinite, which appears to have been destroyed suddenly and in great multitudes, probably by the same cause as that which changed the nature of the material deposited. These encrinites, therefore, were, at the same moment, destroyed and embalmed. The Bradford clay, as this bed is called, was a very local deposit.

The land, in whichever direction it extended at this period, probably included a considerable area, though, from the rarity of terrestrial fossils, it is pretty clear that it did not stretch away towards the east in the direction of the present continent of Europe. On the contrary, the existence of marine but shallow-water fossils on the coast of Normandy, nearly identical with, and embedded under the same conditions as those in England, would rather seem perhaps to point to the south-west as the range in which we may expect to trace it. This land was clothed with vegetation, consisting chiefly of zamias, cycadeæ, and such plants, and these, with ferns and coniferous trees, may have at once sheltered and provided food for the inhabitants. But what were these inhabitants? In the deep forests we might certainly have seen large beetles; near marshy places many flies abounded, and a few small opossum-like quadrupeds tenanted the earth; but with regard to other inhabitants of land and of the sea, our knowledge of existing animals would hardly give very definite information.

But analogy will still teach much that is interesting and important even as to this point. Let us imagine ourselves placed on a projecting headland or hill of mountain limestone, anciently, as now forming a prominent and picturesque object, but commanding a view of the open sea, which then covered the greater part of our island. Placed in imagination in this commanding position, let us endeavour to recall the scenes once enacted near some tract of low flat land—a sandy shore of the oolitic period—on which, at a distance, a few solitary palm trees stand out against the blue sky, but which is backed by a more luxuriant growth of pines and ferns, extending towards the interior, and crowning the tops of distant high ground.

The first object that attracts attention might be one of the crocodilian animals with its long slender snout, and with extremities admirably adapted for swimming, combining those peculiarities of structure which distinguish the *Teleosaurus.** This animal might be seen moving slowly, and not without difficulty, towards the water, but when there, darting abruptly along, pursuing and devouring the small fishes that swarmed about the shallows; these fishes, sluggish in their nature, and chiefly feeding on the mollusks which inhabit near shore, falling a ready and abundant prey. Many other crocodilian monsters, of similar habits, but more or less adapted for a marine life, might also have been seen wandering about seeking and devouring food.

While, however, this was going on in the near vicinity of land, our supposed position would enable us to watch also the open sea at a little distance. Here we could not fail being struck with that most gigantic of all reptiles, the *Cetiosaurus* (see *ante*, p. 192,) easily recognised by the dark outline of its huge head raised partly above the surface to enable the animal to breathe, while at the distance of some twenty yards from this would be seen its great fish-like tail. Could our power of vision enable us to see beneath the surface, there might also be observed those singular webbed feet, and enormous toes armed with long powerful claws, which so strikingly characterize this creature.

But another of the monsters of the deep demands our notice—a truly marine reptile—gigantic in its proportions, admirably adapted for rapid motion, and combining some of the terrestrial and crocodilian peculiarities of the long-, necked Plesiosaurus, with the compact proportions of the great fish-lizard. Its huge crocodilian head contrasts strongly with the porpoise-like body, which is attached without any intervening neck; and its powerful elongated extremities make up for the absence of a vertical tail-fin. The sharks, which were still abundant and powerful, and even the Ichthyosaurus itself, could scarcely have escaped from these terrible enemies.

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* This animal must have very closely resembled the narrow-snouted garial of the Ganges, but its extremities were better adapted for swimming.

Having thus obtained glimpses of the sea and its inhabitants, let us next turn our attention to the adjacent land. The long-snouted and other crocodiles, which have gorged themselves with fish in the shallow water, now sleep half-buried in the muddy and naked plains on shore. Some of them, eighteen or twenty feet long, advance on land with difficulty, their extremities being far better adapted to swimming than walking.

Presently a noise is heard, and a huge animal advances, whose true nature and habits we are at first at a loss to understand. In its general proportions it is far longer and also taller than the largest elephant; its body hangs down near the ground, but its legs are like the trunks of great forest trees, and its feet form an ample base for the vast columns which press upon them. Instead of long tusks, large grinding teeth, and a trunk like that of the elephant, this animal has an exceedingly elongated and narrow snout, armed throughout with ranges of sharp and strong knife-like teeth. The monster approaches, and trodden down with one of its feet, armed with powerful claws, or caught between its long and narrow jaws, our crocodile is devoured in an instant.

But there is yet another scene for us to contemplate. Still remaining at no great distance from the shore, but advancing inland towards the forest, let us watch the golden beetles, and the beautiful dragon-flies and other insects, as they flit past in all the brilliancy and cheerfulness of luxuriant and untamed nature.

The lofty forest trees, perhaps not much unlike some existing but southern pines, are woven together with thick underwood; and the open country, where it is not wooded, is brown with numerous ferns, still the preponderating vegetation, and distributed in extensive groups. Here and there a tree is seen, overturned and lying at its length upon the ground, preserving its shape, although thoroughly rotten, and serving as the retreat of the scorpion, the centipede, and many beetles. A few quadrupeds not larger than rats, but of marsupial structure, are distinguished at intervals, timid even in the absence of danger, and scarcely appearing from their shelter without great precaution. These feed upon the grubs and other insects living upon or burrowing into the ground.

A strangely formed animal, however, is perceived running along upon the ground: its general appearance in motion is that of a bird, but its body and long neck, its head and wings, are not covered with feathers, but are either quite bare, or perhaps resplendent with glittering scales; its proportions are quite unlike those of any known animal; its head is enormously long, and like that of a crocodile; its neck long and outstretched, or thrown back on the body; its fore extremities have four free toes, but the fifth toe folded down on the body; its hind legs are short, and its feet perhaps webbed. This animal, running along upon the ground, pursues and devours the little quadruped we have been watching, and then perhaps darts off towards the sea to feed upon the fishes, which its peculiar powers would enable it to take, either pouncing upon and so transfixing the victim, or even occasionally wading or diving in search of prey.

But we have not yet noticed the strangest phenomenon.

This mailed reptile, four of its fingers still free, but the fifth opened out, and by a connecting membrane forming a wing of very large size, rises into the air, and flits about or hovers over-head, realizing and even surpassing, in the conditions of its existence, the wildest mythological accounts of flying dragons which we read of, or those representations which we see pictured by the pencil of the Chinese. There is scarcely any freak of the imagination, however wild or vague, that does not seem surpassed by some reptilian reality during this remarkable period.

Modified, no doubt, by considerable and even important changes in matters of detail, but still remaining in all essential points the same, the picture thus given may be looked on as neither false nor exaggerated, however imperfect, and as, to a certain extent, characterizing the whole of the long period during which the oolites were being deposited. From time to time, in various places during this period, coral reefs were formed, mud-banks accumulated, and occasionally a considerable quantity of sand was also brought in; and thus there went on a series of changes, resulting in the formation of many important beds of limestone and much clay, along a coast-line gradually advancing eastwards, and probably undergoing numerous alterations of level.

At length this terminated, and a large tract of land was brought very near the present coast of Germany; while, in central Europe, the sea was deepening, and scarcely even a chain of islands indicated the great mountain ranges of the Alps, the Pyranees, the Carpathians, or the Caucasus. At this time it is most probable that no great east and west subterranean movement had acted on the part of the earth's crust now above water in the northern hemisphere, and possibly the first intimation of such a disturbing force may be traced, though faintly, in the existence of a considerable estuary, in which our Wealden beds were deposited. From the condition of the upper Portland beds, we find, that, just at the close of the oolitic period, there were very numerous changes of level induced over a small area in the south-east of England, then most likely not far from the coast-line of a large continent.

Although, however, we have good proof of the existence of a considerable tract of land, the number of species of land animals preserved in the Wealden beds is exceedingly small, and the vegetable remains, though numerous, are nowhere abundant or greatly varied. They are, however, sufficient to prove that very little change had taken place since the commencement of the secondary epoch.

With regard to the animals, we still find reptiles greatly preponderate, and almost all the principal forms still continue. The great marine saurians, the carnivorous land species, and those adapted for flying, and the true crocodiles and animals allied to them, are chiefly abundant; but there have not yet been found any remains of quadrupeds, or any that can with certainty be referred to birds. Turtles and fishes of various kinds seem to have been very abundant, and besides these we have two new reptiles adapted for land, one of them, at least, being a true vegetable feeder.

The atmosphere in the low flat district on this border of a continent, and near the issue of some considerable river, may possibly have been loaded with carbonic acid gas, the result of the rapid and constant decomposition of decaying organic matter in a damp swampy tract, and in this respect the condition may have resembled that now observable in the Sunderbunds, on the delta of the Ganges.

Surrounded thus with a constantly renewed vegetation, in an atmosphere and with climatal conditions probably admirably adapted to its habits, there existed another monstrous animal, more unwieldy even than the megalosaur, and treading down whole forests in its advance, organized so as to clear away a portion, at least, of the results of a rapid growth of vegetable matter. This animal must have been very abundant near the spot where its remains have been met with; it has not, however, as yet, furnished sufficient material to enable us to complete, even in imagination, its singular figure. It was accompanied by another monster, also of large size, and adapted to move about on land with its body high above the ground, but concerning whose general appearance we know even less than in the case of the Iguanodon.

These animals may be considered with great reason as the true representative in time of some of the gigantic vegetable feeding quadrupeds of more recent geological periods; and if this is the correct view, it becomes probable that more nearly allied species belonging to the class Mammalia were really absent. Even in that case, however, it is necessary to bear in mind, that, although absent in these latitudes, and in our European area, they may still have been abundant in other districts, and in tracts of land existing under different conditions.

The delta which had so long been in course of formation, and on which so thick a bed of sandy detritus had been deposited, was at length concluded by a considerable bed of clay which covered up the sand. The land so long above the water again sunk far beneath its level, and the great ancient continent of Polynesia was obliterated during a long time, deep sea deposits being formed in the same tract, and extending with great uniformity over an area of many thousand square miles.

CHAPTER X.

THE INHABITANTS OF THE EARTH DURING THE CRETACEOUS PERIOD.

THE newest portion of the great middle epoch commenced soon after the termination of the deposits from that great river whose delta formed the Weald of Kent and Sussex, and traces of whose existence we find also in the Isle of Wight and on the coast of France near Boulogne. In the south-east of England, by a gradual depression of small amount, a great tract, once the recipient of fresh water, sunk down and became once more subject to marine deposits. This being the case, it is not wonderful that a great change also took place in the nature of the fossils, and that the whole of the fresh-water species disappeared, and were replaced by others adapted to the new and changed condition of things. A modification of this kind extended also over a wide area, reaching from England to the Caucasus, and perhaps continuing as far as southern India: a new series of animals came into existence throughout the district, while a constant succession of alterations of the level of the sea-bottom sometimes produced slight elevations, but more frequently, and on the whole, considerable depression. In this way was marked the commencement of the new period, and during the early part of it the deposit of the bed called "lower green-sand." This bed is of moderate thickness in England, but of far greater importance in this respect in some parts of the Continent, where it is manifestly the representative of an extensive and long-continued series of operations. During this period the prevailing material deposited was, in England, sand, varied occasionally by calcareous and muddy bands, but on the Continent it includes many beds of limestone. The sands contain a good number of fossils very distinct from those of the oolitic period, so that the deposit of the Wealden beds had either occupied so long a time that the species in the neighbouring seas had died out and been succeeded by others, or else the commencement of the deposition of these beds had been marked by the introduction of a new series of typical forms.

The deposit of lower greensand was probably made in a sea which in the south of England was either shallow, or at least not extremely deep; and the bed of clay called gault, which rests upon the lower greensand, contains forms for the most part quite distinct from it. The group of deposits called on the Continent "*Neocomian*" is nothing more than the typical form of these older or lower sandy beds, either immediately succeeding the Weald or resisting directly on the oolite, though not deposited on the latter beds till after a long interval had elapsed, during which, probably, the oolitic rocks had formed dry land.

The gault, or blue clay reposing on the lower green-sand, is itself succeeded by another thin and less important bed of sand, also containing pale green particles, and for that reason called "upper green-sand;" and this again gives place to the lower chalk. The upper green-sand is generally barren of fossils, and was most likely formed rapidly in a shallow sea. After it was deposited the sea-bottom probably sunk more rapidly, previously to the great change indicated in the chalk beds above.

The depression of the sea-bottom, which probably went on, with few alternations of elevation, during the greater part of the deposit of the chalk, was a very important phenomenon, and altered, as may be supposed, the general character of the marine fauna in almost every important respect. We at once lose the species usually predominant in shallow water and on a coast-line, and either obtain deep sea or free-swimming animals, or else find the deposit singularly barren of all organic remains. But, as it is not to be supposed that a continued depression, amounting in the whole to many hundred fathoms, could take place without considerable effect being produced on the beds beneath the surface, and since such depression was perhaps accompanied by a partial upheaval in some other subterranean tract, it will not be thought extraordinary if the effects of submarine volcanic action are also met with connected with this period. Among such effects may have been the outpouring of large quantities of silica, either in solution in hot water, or thrown out in the state of vapour; and in this way we may possibly account for the layers of flint alternating with the pure white carbonate of lime of which the chalk mainly consists.

In the early part of the cretaceous period the animal kingdom was represented by species which exhibit striking differences when compared with those of the oolites, so far as the Invertebrata are concerned, while the same large marine saurians seem to have been continued. This may readily be understood, if we suppose, that, in the interval between the deposit of the uppermost marine oolites and the lower green-sand there was an extensive tract of land at some distance from the districts examined. I know of no other hypothesis by which the facts can be explained; and this view is extremely probable in itself, and answers the conditions of the problem. To this view I shall have occasion again to recur.

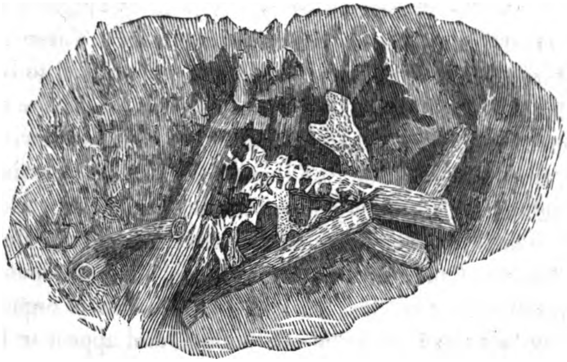
When, however, towards the close of the deposits of green-sand, the sea began to deepen, the character of the fauna also changed, and we find gradually fewer indications of the neighbourhood of land, either by fragments of land fossils, or by any indications of those molluscous animals which prefer for their habitation the shallow water near a coast-line. The animals and other remains of greatest interest that we shall have to consider as characterizing the chalk are thus either free-swimming, or their nearest analogues are known to inhabit deep water. They include sponges, the minute animals called *Foraminifera*, those still more minute microscopical animalcules called *Infusoria*, various forms of encrinites and other Radiata, cephalopodous and other mollusks, a few fishes, and some, but still fewer reptiles. Most of the species are peculiar to the formation, but there is a manifest approximation to the existing forms of animals, not only in those of low organization, but also in the fishes.

In the most ancient seas we find abundant examples of the work of those singular beings, which, in spite of the continual encroachment of the waves, and in defiance of storms and external violence, have always been endowed with a rapidity of increase greater beyond comparison than that of the more highly organized animals. These little creatures have, in the lapse of ages, been enabled to build up the most solid and enduring monuments, and have constructed mountains of coral limestone, which characterize each separate formation; and some of their race continued throughout the secondary period in the part of the world we now inhabit. They were represented abundantly during the deposit of the chalk; and a vast multitude of sponges, organic bodies even less advanced in the scale of organization, were spread over the sea-bottom, and appear to have been destroyed from time to time by sudden irruptions of chalky mud.

The horny net-work commonly known as the sponge is nothing more than the frame-work of a very peculiar kind of vegetable. The whole surface of a living sponge is covered with minute apertures, with large ones distributed at intervals, and the water is in some way made to enter the small pores in a continual current, which passes out again by those of larger size. It cannot be doubted that these currents are connected with the supply of nutrition; but in what way the current is produced, or what are the actual conditions of existence, naturalists have not yet been able to discover.

The sponge as commonly known is made up of horny fibres, but a large number of varieties exist, in which spiculæ, or little needle-shaped crystallized particles of flint or carbonate of lime, separated from the surrounding water, replace these horny fibres, so that the frame-work becomes more or less entirely made up of them, and assumes a different character. A body in this state when exposed to the influence of water in which siliceous or flinty matter is abundantly present, would, as we know by observation in similar cases, attract to itself the particles of siliceous matter in the water, and become fossilized and surrounded with

Fig. 82



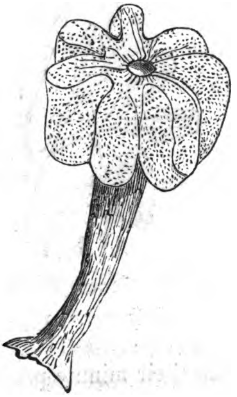
FOSSIL SPONGE SPICULÆ.

silica. Such has been, perhaps, the history of those singular layers of flint which characterize the upper beds of chalk; and it is quite certain that careful examination under the microscope often shows very distinctly in such flints a fine net-work of fibres like those which we know to exist in sponges. The previous figure (82) will give an idea of the appearance of such fibres in flint when greatly magnified.

The forms of the sponges themselves are not unfrequently preserved in that of the flint into which they are now changed, and in this way we occasionally find grotesque shapes resembling in form various familiar objects.

In the sand associated with the chalk, the very spongeous bodies themselves, exhibiting on their surface the peculiar marks and apertures characteristic of them, are also met with in a perfect state. The figure marked (83) represents a common form.

Fig. 83

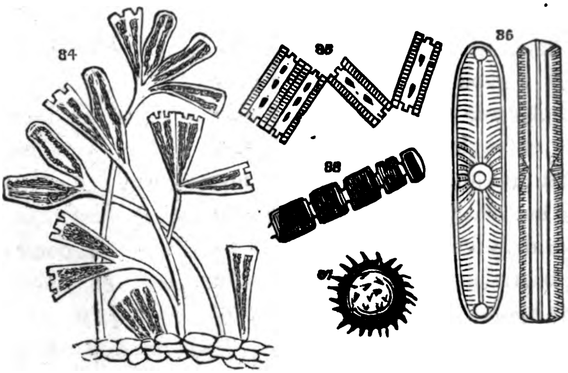


POLYPOTHECIA.

Flints, when examined with the aid of a good microscope, not only exhibit a net-work of fibres, but also show entangled amongst the fibres, a vast multitude of exceedingly minute bodies, the remains of a group of animals known to naturalists as "infusorial animalcules," and of late years investigated with great care by M. Ehrenberg.

The skeletons of these little creatures exist not only in the recesses of the chalk flints, but they also abound in many parts of the solid matter of the chalk itself, so that a large part of this rock would seem to be made up of the fragmentary skeletons of these most minute animals, whose very existence would be unknown to us without the assistance of powerful microscopes.

To give such an idea as can be conveyed by numbers, it will be sufficient to say, that, with regard to some species, as many as twenty-two thousand individuals might be placed in a row on a linear inch of surface, while they are often crowded together so closely in putrid water, that one cubic inch of water in that state contains more of these animalcules than there are human beings on the globe. They increase, too, so rapidly, that, according to a calculation carefully made, as many as 800,000,000 may be derived from a single individual in the course of a month in summer. The method of effecting locomotion and obtaining food is not less singular and interesting in these animals than their minute proportions, and is derived from the possession of very numerous fine hair-like appendages called *cilia*, by the constant vibration of which a current is produced in the water.



INFUSORIAL ANIMALCULES.*

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* *Fig*. 84, Gomphonema. *Fig*. 85, Bacillaria. *Fig*. 86, Navicula. *Fig*. 87, Xanthidium. *Fig*. 88, Gaillionella.

The shapes of the hard part or skeleton of the animalcules found in the chalk, in flints, and elsewhere, are many of them extremely curious and beautiful. Some specimens appear to consist of tubes placed edgeways, and projecting one beyond another; others are also tubes, but placed parallel one with another on long lines of fragile riband transversely to the direction of the riband (fig. 85.) Others, again, are oblong figures united at the edges; while one group, more complicated than the rest, exhibits numerous projections of the most singular shapes (*Xanthidium*, fig. 87.)

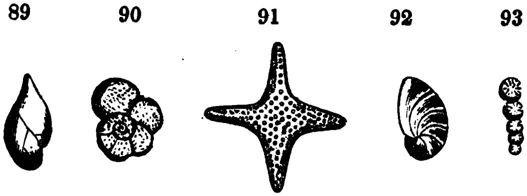
It cannot but be a matter of great interest to learn, if possible, the use of these minute animals in the economy of nature. That they are not merely accidents in creation we may be quite certain, and that they simply enjoy life, and do not contribute to the well-being of the whole, may be considered equally improbable, and too unlike the ordinary course of nature, to be admitted for a moment. All things work together, and we may, in all cases, safely inquire concerning the adaptation of any group, however minute or apparently unimportant it may at first appear.

It has been ingeniously suggested by Professor Owen that these little creatures are the appointed devourers of organic matter immediately before its final decomposition into inorganic elements. "For consider," says he, "their incredible numbers, their universal distribution, their insatiable voracity, and their invariable presence wherever animal or vegetable matter is undergoing decomposition in water. Surely we must be indebted to them—the ever active and invisible scavengers of the world—for the salubrity of our atmosphere; but they perform a still more important office, perhaps, in preventing the gradual diminution of the present amount of organized matter upon the earth.

"And it is not difficult to understand in what way this result is produced, for, when the organic matter is in that state of comminution and decay which immediately precedes its return from the organic to the inorganic world, these wakeful members of nature's invisible police are everywhere ready to arrest the fugitive particles, and turn them back into the ascending stream of animal life. Becoming the food of the smaller infusorial animalcules, they again supply the voracity of the larger ones, and of numerous other small animals, which in their turn are devoured by larger ones, and so, by degrees, the substance fit for the nourishment of the most highly organized classes is brought back by a short route from the extremity of the realms of organized matter."

It is a remarkable and very interesting fact with regard to these animalcules, that their light, though siliceous skeletons, are capable of being transported by the air in the form of fine dust to the distance of many hundred miles out at sea; and the quantity so transported is often sufficient to cloud the air, and form a sensible deposit on the decks and rigging of ships. The microscope alone is capable of proving whence this dust comes, but, with its aid, they can be recognised, identified, and traced to that continent or island, which is not always the one nearest at hand, where they are indigenous. It will not be surprising, also, since we thus find the bodies of the animalcules themselves carried along by millions through the air, that their eggs may be carried yet farther, and prove a bond of union between distant lands, whose other inhabitants have no relation. Who could have imagined that the atmosphere is in this way the means of conveying to distant spots the invisible stony frame-work and the eggs of these little bodies? and yet it is impossible to doubt the importance of such a means of communication in the animal economy.

But the animalcules, singular and interesting as they are, form but one of several groups of animals of low organization that inhabited the sea during the deposit of the chalk. The sea bottom abounded with sponges of all kinds, as we have already seen; and floating about near the surface, there must also have existed a vast number of minute animals enclosed in shells formed of a number of chambers or compartments, belonging to a group now common in many seas and known by the name *Foraminifera.*



FORAMINIFERA.*

The animals thus named occupy all the various chambers of their habitation, and not merely, as in the nautilus, the outermost one. They appear to possess a more perfect organization than the polyps, but are less complicated than the encrinites. Their body is simple and gelatinous, no distinct organs being recognisable in it. In size they vary from dimensions perfectly microscopic, and absolutely invisible to the naked eye, to about the bigness of a five-shilling piece. In shape their habitation is sometimes flat and disc-like, resembling a piece of money, and sometimes it presents the most singular modifications of form, including every variety that can be conceived to arise from the indiscriminate heaping together of a great number of very differently shaped chambers, as unlike one another in size as they are in shape.

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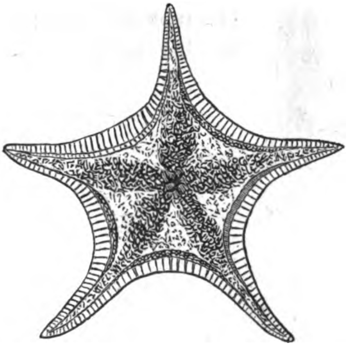
* *Fig.* 89, Guttulina. *Fig.* 90, Rosalina. *Fig.* 91, Siderolina. *Fig.* 92, Cristellaria. *Fig.* 93, Nodosaria.

Animals of this low organization multiply rapidly, and are capable of making very important geological deposits. While, indeed, the vertebrated animals and the larger and more complicated mollusks live for some considerable time, and modify during that time the general conditions of organic existence, these little creatures—the coral animal, the animalcule, and the Foraminifera—may, by their rapid secretion of solid matter from the water, and (owing to their brief existence) equally rapid deposition of it in a solid form, lay the foundation of islands, and even of new continents. The land thus formed may, when brought above the sea level, be destined to last, with little change, throughout many successive geological epochs, during which group after group of species of the higher animals may be introduced and destroyed, some of which leave no indication of their ever having existed, while others are represented by a few bones, a tooth, a scale, or perhaps only by the faint impress of a footstep.

How important, then, it becomes that we should understand these, the common hieroglyphics, even if their meaning is less full, and when they talk an earlier and a simpler language than the others, since the sacred characters which speak of higher events are so infinitely more rare, and for that reason also more difficult to render. The most enduring monuments of man himself—his cities, his pyramids, and his lofty columns—are, in many cases, built of these far more ancient and far more lasting objects, which withstand the shock of earthquakes and the hand of time, and which scarcely yield, even at last, to the slow influence of crystalline forces, re-arranging the particles by the aid of heat and electricity.

Many species of radiated animals—animals developed more or less in a star-shape, and formed of five parts or

Fig. 94



Star Fish.

rays—are common in the chalk (see fig. 94;) but the elegant lily encrinites of the older periods had now dwindled to a few species of small size and diminished beauty. One of the less common, but most peculiar forms of these creatures, has the form of a pouch, or rather, perhaps, of an egg open at the top. The whole is built up of plates accurately fitting one another; and arms proceeded from the summit, surrounding the mouth. The shell or case, which was not supported on a stem is known to naturalists by the name of *Marsupite*;* and one cannot easily imagine how an animal provided with so heavy a covering could move about. It may have been permanently attached, though no stem appears, and possibly it was provided with a membrane projecting between the plates, and coating their external surface.

The true encrinites are not very common in chalk, and this is especially the case in our own country. Some remarkable forms occur on the Continent, and one of these is represented in the annexed figure (95,) but they are rarely in a perfect state.

Besides these radiated animals, many others of various kinds, and perfectly enclosed in a stony case, such as sea-urchins, &c., are found in the chalk, especially in particular

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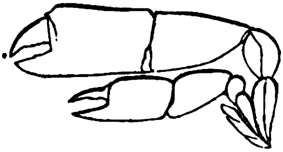
* *Marsupium*, a pouch or purse, from the resemblance of the shell to a pouch.

Fig. 95

BOURGUETI-CRINUS.

localities, and are accompanied by the remains of crabs and lobsters, some of them belonging to that tribe of hermit-crabs (fig. 96,) which have no calcareous covering except upon the claws, and are obliged to make use of the shells of whelks and other univalve mollusca as habitations. It is interesting to be able to trace the similarity of organization which enables us to recognise a character and habit of this kind, for it gives a reality to the investigations of the palæontologist, and a familiarity and homeliness to his descriptions, which cannot fail to be pleasing and satisfactory.

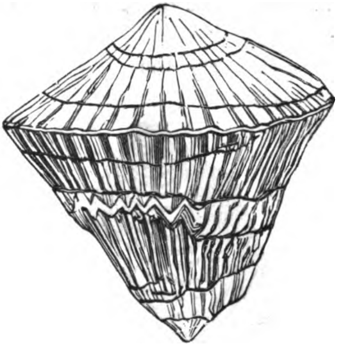
Fig. 96



PAGURUS.

Bivalve as well as univalve shells are found abundantly, but not universally in the chalk; and some districts in the south of France seem to be remarkable for the singular and extreme development of one group, of which, so far as can be told, there are no living representatives. Their shells were permanently fixed to some solid body. The structure of the shell is peculiar and of great thickness and strength, from which we may safely conclude that the animal had no need of motion when once established in its house. One such genus is called *Sphærulita*, another the *Hippurite;* but there are several belonging to this group, and they seem most nearly allied to the inhabitants of those univalve shells of which the limpet is the present representa-

Fig. 97

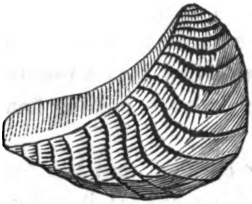


SPHÆRULITE.

tive. I have figured a species of Sphærulite, to give an idea of the ancient form of the shell of this group.

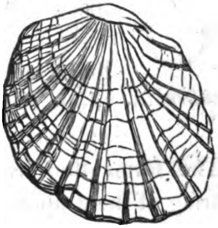
Three common and characteristic forms of cretaceous bivalve shells are also figured. One of them, called *Inoceramus* (fig. 100,) is a shell whose remains are frequently found in the chalk, but which has no living representative. It often attains a large size, and its hinges being singularly thick and ponderous, while the shell was often thin, it is not uncommon to find fragments of the more solid portion detached. The *Trigonia* (fig. 98) is the ancient representative of a genus still found, and not uncommon on the coast of Australia, but now absent from the northern hemisphere; and the other, *Plicatula* (fig. 99,) is one of a larger group, nearly allied to the oyster, and very common throughout the cretaceous period. The Terebra-

Fig. 98



TRIGONIA.

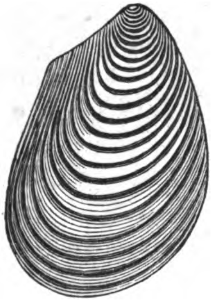
Fig. 99



PLICATULA.

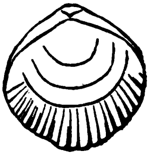
tulæ (fig. 101) were also abundant during the whole period, and continued quite to its close.

Fig. 100



INOCERAMUS.

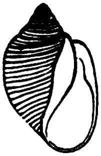
Fig. 101



TEREBRATULA.

The univalve shells of this period are also interesting. Of those nearly allied to existing forms, the annexed figure (102) is a good example. But the most remarkable beyond all comparison, are the indications of the ancient Cephalopoda at this the last point of their development. These animals, having been developed throughout the lias and oolitic period in extreme abundance, were continued in the cretaceous rocks, and there seem to have expanded into a vast multitude of strange forms before becoming finally extinct.

Fig. 102

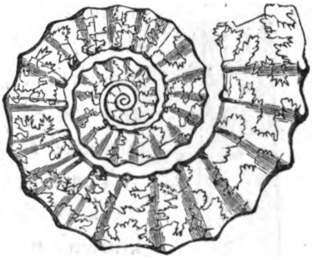


TORNATELLA.

The forms thus assumed were curious, and the exact bearing of them upon the habits of the animal it is by no means easy to recognise. The most simple form in which an animal forms a habitation consisting of a number of compartments may be understood by examining any univalve shell. The greater part of the animal is enclosed in a muscular sac called a *mantle*, capable of depositing carbonate of lime. As soon as one coat is deposited, which of course, assumes the shape of the muscular mantle, the simple shell is perfected. If, as the animal grows, it is developed in a spiral form, the shell increases at the aperture; but if the extremity does not adapt itself to the original shell, and remain always of the same size, it must, as it increases in size, withdraw itself from its former compartment, and build a wall of partition, and in this way we have the first step towards the formation of the shell of the ammonite or nautilus, the generic distinction being founded partly on the position of a siphon or tube which connects one chamber with another partly on the shape of the mantle.

It is easy to imagine, however, that in thus developing itself round an axis, the successive whorls may or may not actually touch one another. The common Spirula is an example of the latter structure in a recent shell; and the shell called *Crioceratite*[*] (103) corresponds with the ammonite, much as the spirula corresponds with the nautilus.

Fig. 103



CRIOCERATITE.

Again, if, instead of being thus formed continuously in a spiral, the animal at particular periods of its growth went off in a straight form, and then again curved, we should have a hooked shell resembling that figured in the annexed cut, and called a *Hamite*[†] (104,) or another having a more boat-like form, and called by naturalists *Scaphite.*[‡] But if,

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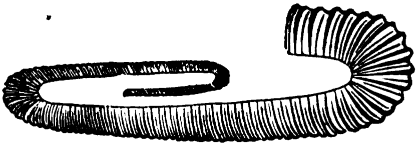
[*] Κριος (*crios*,) a battering-ram; κερας (*ceras*,) a horn.

[†] Αμη (*hamē*,) a reaping-hook.

[‡] Σκαφος (*scaphos*,) a boat.

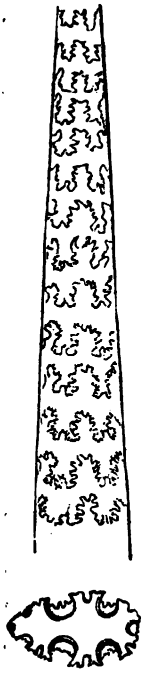
Fig. 104



HAMITE.

instead of curving, it went on straight from the first, we should then have a straight shell, in all important respects the same, but having the same relation with the Orthoceratite that the Crioceratite has to the Spirula. Such a shell is called a *Baculite** (105.)

Fig. 105



BACULITE.

And, lastly, if our ammonite in building its habitation were developed so as to exhibit a form like that of most univalve shells, another genus would be formed identical with one common in the chalk, and called *Turrilites*,† from the spiral or turretted shape assumed.

These peculiar forms (and besides those we have described there are many others known) would not seem to require any great difference in the animal either with regard to structure or habit, but they were no doubt accompanied by well-marked distinctive characters. It is certainly not a little striking, that, at the close of the secondary period, immediately before the whole race of ammonite-like shells was absolutely destroyed in the European seas, there should have been so singular and almost fantastic a development of them. They were accompanied by belemnites, and probably by many free-swimming soft cephalopods, whose remains are not preserved.

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* *Baculus*, a stick.

† *Terris*, a tower.

The fishes of the cretaceous rocks are interesting, although not remarkably different either in form or size from those of the other secondary deposits. They include, however, a number of families referred to those two orders of fishes which now infinitely exceed the other two in number and variety of form (the ctenoids and cycloids,) but which till the chalk had not been introduced upon the earth. Among the chalk fishes there are also some of the sauroid family, among which the species of a genus called *Macropoma* were the most abundant and the most predaceous.

Fig. 106

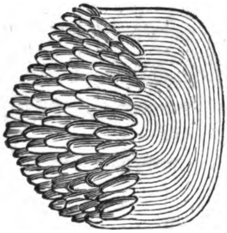
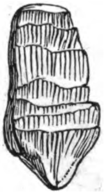


Fig. 107



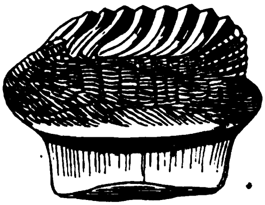
Scale and Coprolite of Macropoma.

This fish was about eighteen inches or two feet long: the head occupied nearly one-third of the whole length, and was provided with strong jaws armed with numerous sharp conical teeth. The body was covered with oblong scales (106) studded with hollow tubes. The fins were powerful, and strengthened with bony spines, which were probably defensive; and the whole skeleton is of robust proportions, and indicative of great strength. Some specimens of this fish have been so well preserved, that not only do the gills remain, but the whole stomach may be seen, with its membranous walls solidified, and with a number of coprolites in the abdominal cavity (see fig. 107.)

Besides these sauroid fishes, which were unquestionably very predaceous, a vast number of sharks of different kinds must have existed, their teeth and bony spines being found abundantly, although generally detached in various places in the chalk. The scales of placoid fishes not enclosing the animal in a bony case covered with enamel, as is the case with ganoid fish, and the skeleton being either nearly or entirely cartilaginous, the body would speedily undergo decomposition after death, so that the different hard parts,—the teeth (108,) palatal bones (109,) and fin rays,—became irregularly distributed. It is in this manner accordingly that we find them.

Fig. 108

Fig. 109



Sharks' Teeth.

The fishes in the chalk allied to the existing cycloid and ctenoid orders are best illustrated by an account of the *Beryx*, closely allied to the perch, and the *Osmeroides*, whose nearest analogue is the salmon.

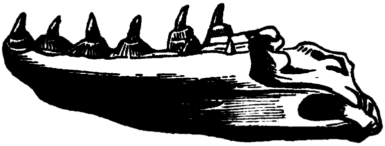
The Beryx is a very common fish in the chalk of the south-east of England, and there are there found three distinct species. All of them are of small size, the largest not more than a foot long, but the scales are very large in proportion, and the head is also very large, at least in some species, while the vertebræ are short and the ribs slight. The jaws are covered with a band of very fine teeth, like the hairs in a brush. The scales are jagged like the teeth of a comb, and the fish belongs, therefore, to the ctenoid order, of which that structure of the scale is characteristic.

The cycloid fish *Osmeroides* is also common in the chalk, but belongs rather to the lower than the upper beds. The fishes of this genus are very beautiful, and often tolerably perfect, but their size is not large. Fishes of the carp family, others allied to the mackarel, and an eel-shaped fish called *Dercetis*, form the remaining groups most abundant in the chalk, and most characteristic of the formation.

The reptilian remains of the cretaceous series are exceedingly few, and present but a scanty amount of new material with reference to this department of fossil natural history. They include, however, one new and gigantic lizard of marine habits, nearly allied to the monitors (*Mosasaurus;*) and with this are found a few remains of turtles, one very gigantic saurian whose structure is little known but which has been called *Polyptychodon* (occurring in the lower beds,) the remains of a few Ichthyosauri, and fragments of a Pterodactyl.

Of these reptiles, that which has been named *Mosasaurus* (the saurian of the Meuse, on whose banks the fossil remains of it have chiefly been found) resembled the monitor of India and Egypt, especially in the structure of the head and teeth; but the head alone is far larger than the whole body of any existing species of these animals, and the teeth, which are of proportionate size are solid and firmly imbedded in the jaw by a broad and strong bony attachment (fig. 110.) The powerful teeth thus inserted were renewed by young teeth, which pressed against, and thus gradually wore away the old ones, and replaced them as they were required. Other teeth of smaller size, but still large, were fitted on the palate, as in the serpents and many fishes.

Fig. 110



MOSASAURUS.
Portion of Lower-Jaw.

The back-bone of the mosasaur was admirably adapted for enabling the animal to move rapidly and easily in the water, and the tail seems to have formed a powerful vertical oar of large size and great strength. The paddles, too, were of gigantic proportions, and in this respect this chalk reptile must have rivalled the Plesiosaurus. All the analogies of the genus, however, seem to have been with the lizard tribe, although involving a perfect application to marine habits, which necessarily introduced considerable modification of structure. The habits of the mosasaur were highly predaceous, and it seems to have been the last gigantic form of the marine reptiles before the final destruction of those animals at the close of the secondary period.

The turtles of the chalk and greensand hardly exhibit any peculiarities which demand consideration here. They are not of large size, and they all belonged to the group inhabiting the sea. Their remains, although not common, include several species.

The gigantic reptile of the greensand called *Polyptychodon*[*] is known only by such imperfect fragments that we can scarcely do more at present than indicate its vast proportions. The thigh-bone of this animal was solid, and measured nearly four feet in length.

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[*] Πολυπτυχος (*polyptychus*,) having many folds or wrinkles; οδους (*odous*,) a tooth.

The remains of Ichthyosaurus and Pterodactyl in the chalk are beyond question, and the specimens are of great interest. The former is known by a very beautiful specimen of the head with the teeth, and the latter by the head, and also several of the long bones.

The bones of birds have been determined among the fossil remains of the chalk; and although very rare and in fragments, they seem to indicate, beyond a doubt, the existence of a large species allied to the albatross.

No trace whatever of the existence of any land quadruped, or of any of the whale tribe, has been met with in the chalk, or in any of the associated or contemporaneous beds. This entire absence of the Mammalia cannot but be looked on as an interesting and remarkable fact.

The conditions of existence during the chalk and the cretaceous beds generally were certainly different from those which obtained during the oolitic period; but this must have been partly the result of circumstances, since the specimens found in the newer deposits afford information only with regard to the inhabitants of deep water and the open sea, and offer little help in determining the nature of the coast-line. It thus becomes probable that a great part of this difference may, after all, have consisted in a change of the relative level of land and water. However this may be, the group of organic remains in the chalk is not sufficiently perfect to allow of our picturing to ourselves any general view of the various races, or obtaining a notion of the characteristic features of the marine fauna as distinct from those of former and later times.

On the whole, however, the geological naturalist, recall-ing the different groups of animals then most abundant, and comparing them with those of more recent and also of more ancient dates, will be struck with many manifest signs of approximation to the existing condition, and may trace a gradual but uniform advance towards the present forms of life.

Such general views, forming what is sometimes called the physiognomy of a group of animals or vegetables, are far more important than might be thought at first sight, for they often point distinctly to the truest and most valuable analogies; and, being, dependent on the degree of uniformity of the condition under which the inhabitants, whether of land or water, may have existed, they are in themselves real and to be depended on. At the same time, it must be remembered that there are kinds as well as degrees of analogy, and that resemblance, of whatever kind or degree, by no means involves true affinity or derivation from the same source. So far is this from being the case, that we sometimes, on the contrary, find the most nearly allied species existing under very different conditions, and forming part of a group whose physiognomy is distinct; while, on the other hand very different species traceable to sources altogether different, may, and often do, show the greatest physiognomical resemblance. We shall consider in the next chapter how the different portions of the great secondary period are distributed, and to what extent they are alike.

Before concluding these general remarks on the chalk, it is necessary that I should here notice, however briefly, the uppermost beds of this period in Europe; those, namely, that occur, on the banks of the Meuse near Maestricht. From various appearances it may be concluded that this deposit took place not far from the shore. There have been found there, for instance, the most perfect fragments of the Mosasaurus, the bones of turtles, &c., together with various remains of crustaceans and shells, which bespeak shallows occasionally left dry by the tide. No remains of birds have, indeed, yet been obtained from this spot, nor is there any indication of the extent or direction of the land; while, from the smallness of this deposit, and the absence of distinct land fossils, it might almost be concluded that there existed only a few scattered islets in these European latitudes. This locality is chiefly interesting from the negative fact, that no modification of the fauna is introduced in it. There is little positive evidence to be derived from the few fossils there presented; and when we consider the aspect of the most ancient tertiary fauna, it will be seen to bear no marks of any association with this, which appears to represent the newest chalk period. If, indeed, any traces exist of the intervening deposits between the true chalk and the lower tertiary beds, they must probably be sought for either in South-eastern Europe, or in those parts of Africa and Asia which form the connecting link between India and the Mediterranean.

The Geology of the newer secondary period in these districts, although at present indistinctly worked out, is gradually assuming interest and importance. It is true, that, in spite of many appearances, some of them very deceptive, there is not yet distinct evidence of a passage from the secondary to the tertiary period; but there is a greater similarity in the general aspect of the two faunas, a more distinct approximation in the proportionate numbers of different species, and a more marked resemblance in the prevailing types, than has been elsewhere observed. Perhaps the best and the most important similarities are those which occur in the fossils of deep water deposits, and the recent publication of an admirable monograph on the cretaceous fossils of south-eastern India* clearly shows that there exists valuable material of all kinds for great and interesting generalization on this subject, and that, in all probability, time and careful investigation will bring to light other evidence, and perhaps ultimately afford the link which is now missing.

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* Geol. Trans., 2d ser., vol. vii. p. 85 et seq.

CHAPTER XI.

GENERAL CONSIDERATIONS CONCERNING THE SECONDARY EPOCH AND THE CIRCUMSTANCES OF ITS TERMINATION.

We have now considered in succession the various aspects of creation during the period that intervened between the disturbances which broke up the older rocks, distributing them in irregular patches and groups over the earth, and the final close of the epoch by the deposit of the chalk. This bed, originally perhaps calcareous mud, afterwards became hardened under water, and was at length laid bare over a great part of Europe by the elevation of the sea-bottom. The disturbance by which the whole of the Wealden district of England was thus exposed, and the great expanse of chalk which once covered it entirely removed, must have been of later date; and the magnificent phenomena of altered chalk on the coast of Antrim in Ireland and in the adjacent Western Islands of Scotland, and of contemporaneous beds in Germany, Switzerland, and eastern Europe, besides the great disturbances of the cretaceous rocks along the elevated district of central Europe, all clearly show the extent of this disturbance, and the results of it. The commencement of this series of disturbances may be considered to have closed the secondary epoch.

If we consider the case of the British Islands generally, it appears very clear that the great earthquake movements resulting in elevation, which have chiefly left marks of their long-continued action, were of two principal geological periods: those of the first period commencing about the middle of the deposit of the coal, and lasting till the upper beds of new red sandstone were deposited; and those of the second period, not beginning till after the close of the deposit of the upper chalk of Britain, but lasting throughout the formation of the beds of London clay. Since, also, these two periods of disturbance are those at which the most marked difference seems to have taken place in the nature of animal and vegetable existence, we are justified in believing that the frequent succession of disturbances during these periods rendered certain parts of the earth not capable of maintaining their former inhabitants, and that the disturbances lasted so long that the species subsequently introduced were of very different specific character.

Before the commencement of the secondary epoch we must suppose that there existed some considerable tract of land to supply the abundant deposits of woody matter which have since become coal, and the sinking down of this land, and consequent frequent exposure of a fresh surface to the ravages of the sea, may account for the rapid deposition and peculiar character of the new red sandstone, and also of its successor the lias; and I have stated the probability that the oolitic strata were deposited in an ocean bed, sinking during the early and middle part, but rising towards the close, until, at length, at the Wealden period, it was elevated into an extensive and important district, not far removed, though perhaps very different in form and direction, from the land in the northern hemisphere at present. After a time, however, the depression re-commenced, and lasted till a considerable tract of deep water covered the greater part of the existing land of Europe. The depression was probably very gradual, but it must also have been general, for we have good evidence that it included nearly the whole of what is now the Alpine range of mountains, and quite the whole of that extensive range of high ground to the east, which has since been lifted up to form the chain of the Caucasus.

In our own country, and in the northern hemisphere generally, the direction of the elevating force during the first of these two periods was, for the most part, north-east and south-west. This is seen in the Welsh and Cumberland hills, the Scandinavian mountains, and the Ural chain, and in the general strike of the older deposits. It is not, indeed, uniform, nor are the mountain chains parallel, but there is sufficient evidence to prove that there was, in this way, a general impress given.

During the secondary period we have this direction retained in England, the oolitic escarpments affording excellent examples of its permanence: but on the continent of Europe there is much confusion; and even the older rocks in the eastern districts, as in Russia, instead of being consolidated and almost crystalline, are loose and scarcely altered from the condition they may have exhibited when first deposited. It might be worth while to speculate how far it is probable, from this condition, that the whole secondary deposit in Europe took place in a sea limited in extent, surrounded, or nearly so, by land to the west and north, and subject to very constant, but inconsiderable changes of level in that direction, though comparatively quiet in its eastern portion, where there was deeper water. Such a condition would seem to account for the great variety and extent of the deposits, the uniformity of some few of them in certain directions, the persistence of some fossils of high organization (as the Ichthyosaurus, &c.) through several distinct divisions, and the general uniformity of character of the group of fossils in some, but not in all districts. If we look upon the whole period as one of transition in the latitude of Europe, and suppose that the axis of disturbance was shifting from the north and south to the east and west direction, many of the apparent anomalies of the formations will perhaps disappear.

Whatever may be the result of speculations of this kind, the fossils of the secondary period certainly exhibit a very perfect and beautiful series, possessing characters at first difficult to decipher, but almost always capable of being made out by detailed and careful investigation.

Observing the indications given by the different and successive groups of organic remains, we can also learn the changes that have taken place in a particular district; and thus, for instance, in England, we may trace a rapid deposition of limestone in one spot, and mud in another, these being contemporaneous, but having very different fossils. Each of these, again, was succeeded by other beds of the same or different kind, without any long pause, and often, it may be, while the preceding deposit was becoming solid; but the new beds exhibit great local differences and sometimes apparent repetition. One thing, however, is perfectly clear in the midst of all this change, introduction, and substitution of species, namely, that there was on the whole no true advance in the perfection or even the complication of organic forms, between the commencement and the close of the epoch; for, at the outset, we find evidence of the existence of reptiles of the two extremes of organization; in the middle we have merely a vast multiplication of reptilian species, exhibiting very interesting and remarkable modifications, but no new type; while towards the close these all cease, and we revert to the same, or nearly the same, modifications of lacertian structure as at first. Neither in size, number, or affinity to higher forms, nor, indeed, in any conceivable point, can we trace systematic advance in organization in the reptiles of this great saurian period. It must not be forgotten also, that the reptiles were, with the exception of the few marsupial quadrupeds, the animals of most complicated structure, and that they form, in the strictest sense, the characteristic group of the secondary period.

Nor do we find any different result if we examine the other groups. The birds exhibit indications of their existence by a few footsteps in the new red sandstone, at the commencement of the epoch, and a very few isolated bones obtained from the chalk give evidence of their presence scarcely more distinct at its close. No such remains at all have yet been found in any of the intermediate deposits. Just so it is with the mammals. In the lower beds of the middle part of the series we have a few but distinct traces of their presence; these, however, are totally lost in the newer beds, and even in the Weald, a fresh-water deposit, we are still without a single fragment that can be supposed to have belonged to any quadruped, the companion on land of the gigantic dinosaurians.

The Invertebrata illustrate the same fact yet more decisively. A vast development of the highest type, the Cephalopoda, seems to have been throughout characteristic of the period, and one genus alone, that of ammonites, was represented then by many more species that now form the whole group. The belemnites and other free-swimming animals of the same kind (cuttle-fish) were no less abundant, and their remains are found every where, distributed it is true locally, owing to the conditions of deposit being only occasionally favourable for their preservation. Other univalve shells are also met with in great abundance, proving clearly how similar the conditions of existence must have been to those which still obtain in various parts of the world. The abundance of Terebratulæ in particular localities, the presence of other bivalve shells of almost all the different existing families, the development of Foraminifera and minute infusorial animalcules in deep sea deposits, and, indeed, almost every natural history fact presented to us, offers the strongest analogy to similar facts now observable. These facts all prove how greatly the study of existing nature may aid us in working out the problems of the past history of the world, and how nearly the past stands in relation to the present.

But though there are thus very near and important resemblances, neither can it be questioned that there are wide and startling differences. Where now, or during more modern geological periods, we should find remains of elephants, rhinoceroses, and hippopotamuses, we have multitudes of the bones of gigantic reptiles, assuming their form, occupying their place, and substituted for them in the islands and continents of the ancient world. The whale tribe, an exceedingly important and widely extended group of animals, now inhabiting the seas from the poles to the equator, represented by many species of various proportions and dimensions, and manifestly occupying a very important place amongst the inhabitants of the deep, is, in like manner, totally absent. It must be remembered, too, that in this case the argument arising from the absence of the group is far stronger than in the case of land animals, for the remains of these creatures, both of teeth and bones, were just as likely to be preserved as those of other marine animals, and in more modern deposits they have been so preserved. But there is also a good reason for their absence. Their task was performed by others;* they were not needed, because their place was supplied by the gigantic marine reptiles, which have abounded during the whole period, and which have left undoubted marks of their existence and wide distribution.

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* This is the case at least with the large-toothed carnivorous Cetacea. It is worth while to observe that we do not at present know of any fossil remains in secondary rocks of large herbivorous or animalcule-feeding animals, whether reptilian or otherwise, corresponding to the dugong, &c., and the gigantic true whales (*Balænæ*.)

This method of substitution, by which, at different times and in various places, animals and vegetables of very different organization have replaced one another, is found by geological observations to have been universally adopted in nature. Large groups may be observed performing their appointed task at one period or in one place, and these are represented by other species at another time or at some distant spot, the representative species exhibiting some analogous peculiarity, either of structure or habit, which fits it for that similar function.

This important fact is, however, not made known to us exclusively by geological researches, but also by investigations into existing nature; and these latter, when combined with the former, become more distinctly recognised, and by their manifest relation to long periods of time as well as extensive tracts in space, exhibit their true importance with reference to all nature.

Viewed as one epoch, the secondary rocks present to us a well-marked and very distinct group of animals and vegetables, from the careful study of which we may arrive at some probable conclusion with regard to the condition of the earth and seas during the period of deposit. We thus learn to consider the secondary period as indicating a condition very different from that of the earlier epoch, and as cut off from it absolutely by the introduction of new forms of organic existence. Its great characteristic undoubtedly appears to be the introduction of reptiles, or rather the presence of reptiles in such vast variety of form, and in such relative numerical abundance, as to render it probable that the apparent absence of animals of higher organization is not accidental, or a conclusion based on imperfect examination, but that it was real and absolute.

The corresponding characteristic of the former and earlier period we found to be the great development of fishes, which occupied then the position afterwards filled by reptiles. Now it is this apparent substitution or representation that gives confidence and justifies the conclusions drawn. By the help of comparative views of this kind, we perceive the meaning, the symmetry, and the perfectness of each group, and the adaptation of each to its own end. By carefully carrying out the method of comparison, we gradually attain more distinct, less exaggerated, and more rational views of the differences of organic being at various periods; and there is no doubt that the views thus attained are infinitely more real than those derived from the examination of a few isolated facts of marvellous character, which attract the imagination, but which for that very reason are likely to mislead the judgment.

If called upon to give a general account of the physical geography of the secondary period, in the vicinity of our own island, I might venture to suggest,—1. That during this period there were many inconsiderable disturbances of the bed of an ocean which then covered our island, but which was partially bounded in several directions by islands extending to the west and north, the lines of coast being more or less extensive, and generally at no great distance. 2. That the effect of these disturbances was for a long time gradually to depress the bed of the ocean, while the deposits, chiefly of calcareous matter, were sufficiently rapid and abundant, at least near shore, to keep pace with the sinking. 3. That after a time partial elevation took place, converting into dry land a large tract, in consequence of the wide extent of a moderately shallow sea, arising from the condition just mentioned. 4. That there was an exception to this conversion into dry land in the southeast of England, and some other spots; but that here the waters were chiefly fresh, indicating the presence of an extensive river emptying itself not far off into the sea. 5. That while this elevation took place in England, depression was going on in the south of Europe, accompanied by disturbances, and producing a deep sea. 6. That such deep sea was afterwards enlarged by a wider movement of depression, until it extended from Scandinavia to Spain, and from England to the Caucasus, being throughout that wide tract the recipient of deposits of chalky mud; and, finally, that this sea was probably deeper and was soonest deepened in the southern part of the district, but that just in that part the sea-bottom afterwards again underwent elevation on a grand scale, and formed either continuous land or a chain of islands extending from England to Asia Minor, and connected with the elevation of the Alps, the Pyrenees, and the Caucasus.

This last disturbance was accompanied, however, by a total destruction of almost the whole series of animated beings in these parts of the world; it was accompanied also by the outburst of a considerable quantity of lava (seen in the north of Ireland,) and by the production of the central mountain districts of Europe and Asia. In this way was given the first decided tendency to the great east and west line of direction which was afterwards retained during the elevation of the eastern part of the northern hemisphere.

How long it was after the deposit of the chalk that these movements commenced, and how long they lasted,—whether, as is probable, they began early, and lasted for a very long time, or whether they commenced only when the chalk had become hard and attained its present condition, —we are not able yet to assert; but there is little doubt that the great secondary period was locally terminated by disturbances connected with the elevation of Europe and Asia, while possibly at this very time deposits were going on in the seas immediately adjacent, and over a great part of the valleys in those two continents.

These, we believe, are conclusions which Geologists will hardly be inclined to dispute, and they form the outline of a connected history of the revolutions of the globe during the secondary epoch. But, besides that part of the history which has immediate reference to British Geology, there are other important facts already known with reference to other districts. The successive elevation of the Alps, the Pyrenees, the Carpathians, the Caucasus, and the Himalayan chain, and even of the Andes, will also be found to bear importantly on the general physical Geology of the epoch, and will tend to clear up many doubts and difficulties that arise in the contemplation of the phenomena as they are presented in our own country and in western Europe.

THE THIRD, OR MODERN EPOCH.

CHAPTER XII.

THE INTRODUCTION OF LAND ANIMALS AND THE COMMENCEMENT OF THE TERTIARY PERIOD IN WESTERN EUROPE.

THE close of the secondary period was succeeded by a general disruption of the various beds that had been deposited in those parts of the earth to which we now have access, and by changes and modifications so considerable as to alter the whole face of nature. It would appear, also, that a long period of time elapsed before newer beds were thrown down, since the chalky mud not only had time to harden into chalk, but the surface of the chalk itself was much rubbed and worn.

So completely and absolutely is the line of demarcation drawn between the secondary and newer deposits in parts of the world where these beds have been recognised in actual contact, that it had become a common notion among Geologists, to assume the destruction of all natural relations between them, concluding that not one single species of animal or vegetable connected the two periods, and lived through the intervening disturbances. Although this view certainly requires modification in points of detail, it is still correct in a general sense, and expresses, without much exaggeration, the real extent of difference in condition, the result, perhaps, a lapse of time greater than is elsewhere indicated. In this way the secondary period is distinctly cut off from the tertiary. It is scarcely less separated by the fact that in the former we every where find marks of the presence or near vicinity of the sea in all the deposits, even those from fresh water, while, in the newer beds, land animals at once assume the importance which they have ever since retained, having been evidently present in great numbers and variety.

Confining ourselves, at present, to the principal localities of older tertiary deposits in Europe, we find distinct indications, from the nature of the beds themselves, that they were deposited with a considerable degree of regularity, and even uniformity, and not in a very short time. The beds are extensive, and consisted at first of such rolled pebbles as might have been produced by the rubbing and wearing of the chalk flints on a shingle beach. The rocks were broken into small and similar fragments, rolled until they were perfectly smooth and either round or oval, and thus appear of nearly uniform character throughout widely distant tracts. Whatever, therefore, was the condition of the district now covered by the older tertiary beds of England, France, and Belgium, during those ages that elapsed between the final deposition of the chalk as we now see it, and the deposit of pebble-beds upon its worn surface, the cause that brought into existence these beds seems to have been connected with the re-introduction of a coast-line, and a shallow adjacent sea-bottom. Whether, as is highly probable, a deep sea at first covered all these districts, and, owing to comparatively rapid and repeated elevation after the deposit of the chalk, the change of depth destroyed, without allowing to emigrate, the species of animals of whatever kind that inhabited the ancient sea, or whether a considerable tract of land was formed in an east and west line, cutting off communication between districts not far removed in latitude, and extending, perhaps, from Asia Minor far out into the Atlantic: these are points which Geology does not, at present, enable us to solve. All we know is the great fact of the absence of the chalk species in the tertiary-beds, their place being supplied by new species, for the most part of very different organization. We thus have to enter upon a new series of phenomena, when we turn from the contemplation of the secondary to that of the tertiary period.

When, however, the time had elapsed, and the change had taken place,—and it must be repeated that the interval, whether long or comparatively short, was marked by the destruction of nearly the whole marine creation,—when, after this, the sea-bottom in these parts of the world again received accumulations of mud and shingle, it is not unlikely that a great elevatory movement had already commenced. From the general direction of the subsequent disturbances which brought to light the Wealden district in England, and elevated the Alps and the Caucasus, it is almost certain that the line of that movement was, on the whole, east and west.* From the careful examination of Europe, as it now exists, we also learn that the elevation was most considerable in the middle of Europe, extending thence to the western part of England along what is now its southern coast; marked by a parallel movement in the line of the Pyrenees, the corresponding range on the east coast of the Adriatic, and the Caucasus, and producing land enclosing lakes of fresh water in what is now the Grecian Archipelago.

It appears, also, that these disturbances were continued until the close of the middle tertiary period in central Europe, and probably much later in the Caucasus, while they have, perhaps, scarcely yet ceased in the central parts of Asia. They were, however, much earlier concluded in England, and were there succeeded by a long period of tranquillity, our own island being elevated above the sea, and receiving very slow additions, chiefly on its eastern coast.

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* The later, or tertiary movement, seems to have had a north-west and south-east direction, as the former one, effecting the elevation of the oolites of England, was north-east and south-west. The Alps from the central or culminating point, and are transverse to the main direction of the period.

In examining the Geology of the tertiary period we are fortunate enough to find a chain of evidence informing us not only of the existence of land, but of the nature of the vegetation that clothed it, and the animals that inhabited it. This evidence commences even before the beginning of the great disruption which brought up the Weald, and it lasts not only through the period of that disturbance, but afterwards to much later times. Owing, however, to the prevalence of causes which did not permit the preservation of organic remains, we have less evidence with regard to some of the later periods than to those of earlier date. There seems no doubt that the marine fauna of the oldest tertiary seas was totally disconnected from that of the cretaceous epoch.

The first tertiary land concerning which we have distinct knowledge was richly clothed by a vegetation, a good deal of whose general character is recognised by examining the fruits of trees and fragments of wood found abundantly in the Isle of Sheppey. These fossils are exceedingly numerous and varied, and the fruits obtained from the single locality just alluded to include several hundred species, all of which are different from existing and known plants, although many of them seem closely allied to generic forms now met with in warmer climates than those at present characterizing similar latitudes. A portion of one of these fruits is figured in the annexed cut; it marks the existence of a five seeded fruit which was enveloped in a mass of downy filamentous structure. The plant was probably allied to the natural order of *Malvaceæ*. There is, indeed, nothing in these plants which removes

Fig. 111

HIGHTEA.*

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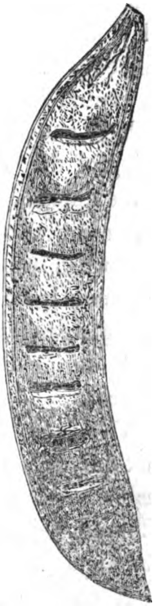
* So called from the name of a botanist, J. Hight, Esq.

them at once and in a marked manner from the existing type; and the most remarkable fact concerning them as a group is the preponderance of species allied to the palms, some of them being apparently intermediate between the cocoa-nut and the *Pandanus*, or screw-pine—well-known and common tropical plants, not met with now in northern latitudes. The recent analogues of another genus, Nipadites (fig. 112,) the family of *Nipæ*, inhabit the Spice Islands and Japan, and chiefly in low damp or marshy tracts at the mouths of great rivers, especially in brackish water. Associated with these are some varieties of the cucumber, or gourd tribe, the pod of a variety of *Acacia* or *Mimosa* (see fig. 113,) the seeds of cypress-like plants, and the fruits of some coniferous trees. There are also fragments of wood and stems indicating the presence of a species of the pepper-plant, —of several varieties of palm-trees, and of several coniferous trees. The wood has often been pierced and almost destroyed by an extinct species of *teredo* before it was deposited in the bed where it is now found; and sometimes it presents little else than a collection of the tubular cavities of these animals filled with carbonate of lime.

Fig. 112

NIPADITES.*

Fig. 113



POD OF MIMOSITES. (London Clay.)

The older tertiaries of the London Basin, of the Hampshire and Isle of Wight Basins, of the Paris Basin, and of the neighbourhood of Brussels, are all contemporaneous deposits, and differ only in consequence of local peculiarities caused by the nature of the material. The oldest part of each, which is every where a coarse pebbly bed, may possibly have once been spread pretty uniformly over the whole tract; but, afterwards, when the land had risen above the sea in various places, and yielded different kinds of detritus, the water in some places was nearly fresh, in others brackish, and in others, again, perfectly salt. In this way all varieties of development are accounted for; and we may understand how the coarse and occasionally flinty limestone found at Paris, the great and uniform mass of clay near London, the marly clay of Brussels, the highly siliceous material, probably deposited from warm springs, in central France, and the limestones of the Greek Archipelago and Asia Minor, all present fossils having something of the same general character, and belonging to the same epoch. In the tertiary beds in western Europe, there is, on the whole, not much distinct uniformity of character; but when we examine the contemporaneous deposits of northern India and South America, we find evidence of the operations of nature having been conducted on as grand a scale during the tertiary as during the preceding geologica epochs.

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* A very common fruit in Sheppey. It contains a single seed nearly in the centre, closely resembling that of the cocoa-nut, and with a very hard shell.

The beds of London clay at Sheppey and elsewhere are not only remarkable for the amount of information they give us concerning the vegetation of the early tertiary period in Europe, but are almost equally instructive with regard to the animal inhabitants of the land at that time.

A considerable number of shells are found, both univalve and bivalve, of which the annexed figures (114—117) will give some idea, but the most remarkable fact concerning them is the absence of the whole group of ammonites, and their replacement by a newly-introduced genus of carnivorous trachelipods (animals of lower organization,) which

Fig. 116

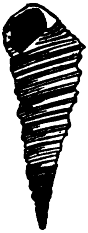


Fig. 114

Fig. 115

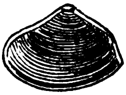
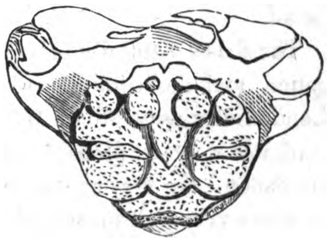


Fig. 117

Eocene shells.*

here abound in the most remarkable profusion. Upwards of two hundred species of these shells (Cerithium, fig. 116) are found in the older tertiary beds of Europe. The nautilus is retained in these beds, especially in the London clay (the most distinct marine deposit) but it has ceased to be the representative of the prevailing group of mollusca. In addition to the shells there are in the beds at Sheppey a multitude of the remains of crabs and lobsters, some of them exceedingly perfect, indicating the vicinity of a coast-line at the time when this part of the series was deposited. One

Fig. 118



Crustacean.

Fig. 119

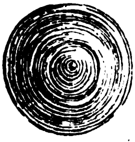
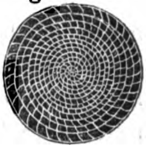


Fig. 120



Nummulites.†

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* *Fig.* 114, Lucina. *Fig.* 115, Corbula. *Fig.* 116, Cerithium. *Fig.* 117, Cone.

† Fig. 119 shows the external surface of the shell, and fig. 120 the appearance of a section, the light parts being the chamber-walls, or septa.

of these is figured (118,) to give an idea of the near resemblance of them to existing species. Figures are also given (119, 120) of a species of foraminiferous shell, called Nummulite (from *Nummulus*, a little piece of money,) whose remains are so incredibly abundant in some localities, that rocks are made up of them, and which, although belonging also to the secondary epoch, must be considered characteristic of some older tertiary beds. Other smaller foraminiferous shells have built great masses of the limestone of this period.*

Besides the numerous shells and other invertebrate remains, the older beds of this newest epoch afford many very interesting fragments of fishes, of reptiles, of birds, and even of quadrupeds. In order to obtain a general view of the eocene fauna, we must consider some of these a little in detail.

The fishes naturally present themselves first for investigation and description, and their remains, as well in the London clay as at Monte Bolca in north Italy, and in a remarkable deposit, probably of the same age, in Asia Minor (Lebanon,) are very numerous. They are not, however, in all cases very well preserved, and this is especially the case with regard to those found in the tenacious blue clay of the Thames valley, where there is frequently nothing to be obtained but a few bones of the head. It is thus far more difficult to determine their analogies than those of the older fishes, where we generally have the whole body. This condition is partly owing to the nature of the bed, which must have been originally a fine mud, in which the fish had rotted after death, when the bones separating, and the fins becoming detached, the thin fragile scales, unlike the bony enamelled case of the older fishes, would not afford a coating solid enough to preserve the integrity of the form.

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* A great part of Paris is built with a limestone of this kind.

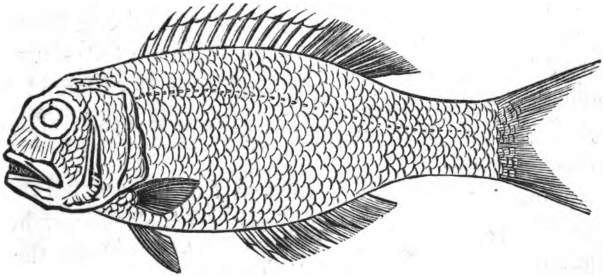
Now, in fishes, the bones of the head are so numerous and variable, that they have hardly yet been reduced to a distinct system, and there is thus the greatest possible difficulty in making out the species. Even after the bones of the skull of the more common recent fishes have been prepared as carefully as possible for purposes of comparison, much difficulty remains, in consequence of the ancient fishes not resembling so much those of our own coasts as those of the Indian seas and Southern Ocean, which are necessarily far more rare, especially in a state to admit of the skeleton being reconstructed. It is a remarkable result of the knowledge and careful research of M. Agassiz, that, in spite of this, he has been able to give a tolerably complete sketch of the fossil fishes of the London clay.

Like the fishes of older formations, the London clay species may be distinguished into groups; but, in consequence of the much nearer resemblance to the recent type, these principally belong to the Cycloid and Ctenoid orders of M. Agassiz, very few indeed of the Ganoid order, so characteristic of the older beds, being here found. In fact, while the whole number of the Sheppey species at present known amounts to ninety-two, and only eleven of these are of the more ancient type of Ganoids, thirty-two being Placoids (chiefly rays and sharks,) while no less than forty-four are distinctly referable to existing families of the Ctenoid and Cycloid orders; most of the latter are very nearly allied to existing species.

Among the principal families of fish represented in the London clay of Sheppey are those of which the perch, the mackarel, the blenny, the herring, and the cod are the respective types. The species of the perch family are by far the most numerous of the Ctenoid fishes (those having the scales jagged like the tooth of a comb,) while those allied to the mackarel are equally predominant among the

Cycloids. It appears, that, of about a hundred and forty-four Cycloid and Ctenoid species of fishes which now inhabit the seas surrounding the British Islands, there are seven species of the perch, eleven of the mackarel, twenty of the cod, eight of the herring, and eight of the eel families; and referring to the whole number (about forty-four) of the fossil species of the two first-mentioned orders found in the London clay of Sheppey, we meet with the same number of species (seven) of the perch tribe, twelve species of the mackarel, four species of the cod, two of the herring, and one of the eel family, while four others of the most abundant recent families are either totally absent or very sparingly represented. On the other hand, there is, besides these, one family, now almost confined to the southern seas, but represented in the London clay by three distinct genera; another (now absolutely tropical,) by a genus nearly related to the existing tropical form: while a third, which includes the common sword-fish, a species of which, inhabiting the Mediterranean, sometimes strays to our shores, was represented by five species referable to four genera, all of which have analogies connecting them with species at present only met with in the southern seas.

Fig. 121

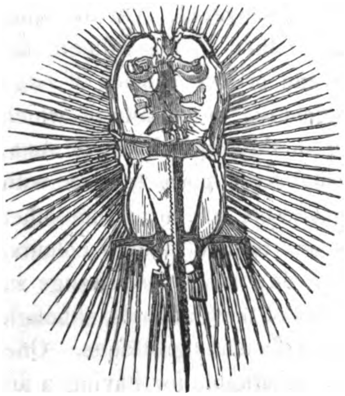


SCIÆNURUS.

As an example of one of the fishes whose remains are extremely common in the London clay of Sheppey, I give a restored figure of the *Sciænurus* (S. Bowerbankii,) which illustrates some peculiarities, as well as shows the general resemblance to existing groups. This genus is of the Ctenoid order, and not very widely removed in its affinities from the perch. It affords an example of unusually perfect restoration from fragments almost always injured and displaced, and it departs so far from modern types, that, although its place in scientific classification can be determined, (chiefly from the scaled cheeks, and the bony plates about the head,) there is yet decided proof of its being a new genus.

It is interesting to find, that, while this and many other marine representatives of the perch and modern allied forms existed, other species now common are unrepresented. The whole of the salmon family as now known is absent; and of the numerous important and useful varieties of the cod only four species have been met with, but few specimens of which have yet been discovered. On the other hand, a tropical family nearly allied to the salmon (the *Characidæ*) is represented by one or two species of large size; and there are others, belonging to a family of which several genera are now living in the tropical seas of Asia, where these animals dart about from place to place with restless activity, and are remarkable above all the other fishes for their singular forms and brilliant play of colours. It is hardly possible to imagine any thing more strange in appearance than the fossil species of these animals, although the recent forms are sometimes sufficiently grotesque. One extinct genus, for instance, is remarkable for having a fin rising like an immense mast from behind the head to a height far greater than the length of the body, a corresponding sail extending from this to the tail, while there are two extremely slender though nearly equally long fins on the belly. Another is, if possible, more singular and preposterous, the height of the body and fins together being three times as much as the whole length of the animal. These fishes are chiefly met with in the Monte Bolca beds of north Italy. From all this it appears extremely probable that the older tertiary fishes existed under different climatal conditions from those which obtain at the present day on the coasts of Europe; a conclusion confirming that arrived at by the examination of fruits and seeds drifted down and deposited in the Isle of Sheppey.

Fig. 122



Fossil Ray from Lebanon.
(Cyclobatis.)

In considering the ancient tertiary fishes of Europe, I have confined myself to an account of those of the London clay, because in the adjacent basins of the same age in Hampshire and the Isle of Wight, in the neighbourhood of Paris and other parts of France, and in Belgium, the fossils found include but few remains of this kind, being chiefly indicative of the condition of the sea with regard to the other inhabitants, such as shells, or else offering illustrations of the nature of the quadrupeds and land animals of higher organization than of fishes. The two remarkable localities already alluded to, that of Monte Bolca in northern Italy, and that of Mount Lebanon in Asia Minor, include also many remains of fishes; and these, although exhibiting different species, still further confirm the general conclusions arrived at from the study of the Sheppey beds of the London clay. A very interesting example has been described lately by Sir P. Egerton, and is figured in the accompanying cut. It is a small but perfect Ray; and the rarity of obtaining Placoid fishes of any kind, even in tolerable perfection, renders this beautiful specimen extremely interesting. It is a male of full age, with a smooth skin, slender tail, and no defensive weapons. It presents so many analogies with the torpedo, that, like the species of that singular group, it may have been provided with a special electric apparatus, to enable it to obtain food and resist the attacks of its enemies.

We ought not to conclude the account of the fishes of this period without referring also to those species of the Ganoid and Placoid orders found in the Isle of Sheppey. The hard crushing teeth of some remarkable Ganoid fishes are found occasionally, and have been described by M. Agassiz, in his great work on fossil fishes. The flat pavement of palatal bones with which these animals were provided probably enabled them to grind to powder the shells of the molluscs and crustaceans on which they fed. Besides this group, there was also a species of sturgeon existing at the period in question; as many as seventeen well-marked species of large rays, besides two saw-fishes; ten species of shark, and three species of the family of *Chimæridæ* or sea-monsters, which exhibit a close affinity to the sharks.

The reptiles inhabiting the land, and the rivers and estuaries near land, at the time of the London clay deposit, exhibit evidence with regard to the question of climate strictly in accordance with that suggested by the examination of the fishes, the molluscs, and the vegetables. Thus we find a lacertian and several crocodilian animals, some turtles and tortoises, and a very interesting addition to previously discovered reptiles, namely, a serpent. The crocodiles of the London clay most nearly resemble a species from the island of Borneo, but are certainly distinct. The tortoises are some of them freshwater, and there are a few marine turtles exhibiting some interesting peculiarities, and connecting the freshwater and marine tribes; but most of the marine species are smaller than those now existing, and resemble species restricted to warm climates.

The serpents of the London clay are extremely interesting, for they are of the tribe now represented by the boa constrictor and python, and attained unquestionably very large dimensions, varying, probably, from ten to upwards of twenty feet in length. Reptiles of this kind only exist at present in tropical countries, and they generally prey on quadrupeds and birds.

The fossil remains of birds from the older tertiaries are exceedingly rare, owing, no doubt, chiefly to the fact, that the fragments of such animals would be rarely conveyed to the sea or estuary where a deposit was going on. Still the London clay of Sheppey has yielded proof of the existence of more than one species of bird which inhabited the land at the time of this deposit, and amongst them is a true vulture, smaller than any now known to exist.

Although the remains of birds are very rare in the marine formation of the London clay, several species have been obtained from the examination of the Paris Basin fossils, some of which more or less resemble the pelican, the sea-lark, the curlew, the woodcock, the owl, the buzzard, or the quail. In a few instances the general outline of the skeleton has been preserved.

We next have to consider the land quadrupeds characteristic of these strata. Such fossils are much more commonly found in the gypsum beds near Paris than in the London clay; but this has no doubt arisen from the circumstances of deposition, since the same or nearly the same groups are indicated throughout the whole district. The

Paris fossils were describèd by Cuvier, and their description formed the first of his long and important series of contributions to the accurate knowledge of extinct animals, which has given such steadiness and certainty to the science of palæontology. The tertiary remains thus serving as the groundwork of the "Ossemens Fossiles" included a considerable number of species, chiefly belonging to the group of *Pachydermata* or thick-skinned animals, now represented by the elephant, &c.; they also include a number of carnivorous animals (quadrupeds,) such as a wolf, a fox, a racoon, &c., and an opossum.

Besides these animals, several of which are repeated among the comparatively rare mammalian remains of our own island, there have been found also in England a few fragments of teeth indicating the existence of a monkey and a bat. These occur in sands of the age of the London clay, and they tend to complete the chain of evidence already alluded to, and render it highly probable that a warmer temperature obtained in these parts of the world during the early tertiary period than at present.

I have already alluded to the apparent predominance of the pachydermatous tribe of animals among the quadrupeds of the Paris Basin, and it is interesting to find that the various genera of this group seem to have represented those of the great tribe of ruminants afterwards predominant. This would seem to show that the state of the land was then less favourable for such animals as are now common in Europe, and renders it probable that a different and more luxuriant and rank vegetation might then have prevailed.

The pachydermatous animals that chiefly attract attention amongst the older tertiary quadrupeds are those which have been named *Palæotherium* and *Anoplotherium*. Besides these there are also many others more or less nearly allied. Most of them exhibit analogies with the horse, and connect the heavy pachyderms, such as the elephant and tapir, with the ruminants. They form a well-marked group, of which the tapir is perhaps the best living representative; and, as all the knowledge that we possess, as well of the structure as the habits of these creatures, must necessarily be comparative, perhaps the best introduction to the description of the extinct group will be an account of the less known peculiarities of the existing type.

The tapir occurs both in South America and in the Indian islands, but the species are, as might be expected, quite distinct. The animal is about the size of a small horse, but it has a short proboscis, and in its general appearance might be considered intermediate between the elephant and the pig. Its teeth are somewhat like those of the rhinoceros, and are adapted for succulent vegetable food. Its skin is nearly naked, like that of the elephant; its habits are semi-aquatic; and though quiet, it has not been domesticated. It seems to pass a solitary existence, buried in the depths of the forests, and never associating with its fellows, but flying from society and avoiding as much as possible the neighbourhood of man. It rarely stirs abroad from its retreat during the day, which it passes in a state of quiet lethargy, and seeks its food only by night. With the exception of the hog, it is the most truly omnivorous of the tribe of animals to which it belongs, for scarcely any thing comes amiss to its ravenous appetite. Its most common food is vegetable, and consists of wild fruits, buds, and shoots.*

The description of the habits of the tapir would probably require little change to be applied to the *Lophiodon*,† a genus of extinct pachyderms most nearly resembling the tapir, but known only by imperfect fragments. A considerable number of species (upwards of twelve) are however known; and one is as large as the largest rhinoceros, but the others are much smaller, and one does not equal in size the smallest variety of pig. Fragments of four species of this genus have been determined from the English eocene beds, and all of them probably inhabited the drier parts of the land.

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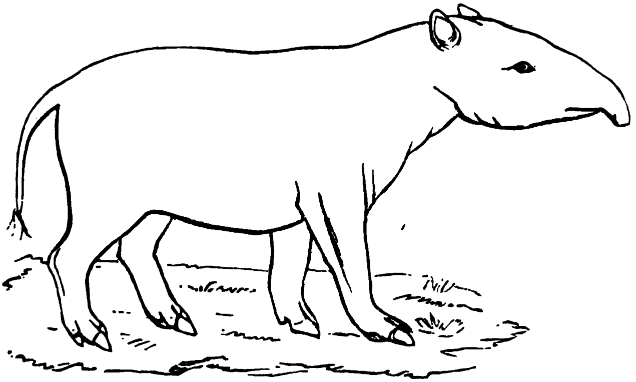
* Gardens and menagerie of the Zoological Society delineated, vol. i. p. 202.

† Λοφια (*lophia*,) a crest; οδους (*odous*,) a tooth.

The *Palæotherium*[*] is much better known than the Lophiodon, probably because it was an inhabitant of districts nearer water, into which its remains were readily drifted. Like the Lophiodon, the different species (which are numerous) varied greatly in size. Portions of the skeletons of these animals have been found in the gypsum-quarries near Paris, so nearly perfect, that their remains no doubt whatever as to the general form and proportions of several of the species. They were all provided with a short fleshy snout or proboscis; and, in the arrangement, number, and general character of the teeth, they combined the peculiarities

Fig. 123



PALÆOTHERIUM.

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[*] Παλαιος (*palæus*,) old; θηριον (*therion*,) a beast.

of the tapir and rhinoceros. Unlike the tapir they had, however, only three toes on each foot. Their legs also were longer, and their general form more slender than that animal, at least in the species of medium size; and in this respect the Palæotherium was probably intermediate between the tapir and the horse.

The *Anoplotherium*[*] may be considered as a still farther departure from the tapir towards the ruminants, having been far less clumsy and more agile in its movements than either the Palæotherium or the tapir. The animals of this interesting group exhibit two peculiarities which are observed in no other quadruped, the feet having only two toes, and the teeth being placed in a continuous series without any interval between the incisors and the molars, as is the case with all other Mammalia except man. For this reason, namely, the absence of tusks, or canine teeth longer than the other incisors, the animal has received its name of Anoplotherium, or "weaponless;" and there are three well-marked sub-genera, all of which appear to have been abundantly present during the older tertiary period. They none of them had a proboscis or produced snout; and in this and other respects they rather resemble the ruminants than the pachyderms; but one species seems to have been well adapted to live in swamps and marshes, and probably for that reason its remains are more common than those of the other forms.

This first species belongs to a division considered typical, and attained the largest dimensions. It was about as tall as a dwarf ass; but its body was longer in proportion, and its tail of enormous size, giving the animal the general aspect of the otter. It is most likely that this species lived chiefly near the water, feeding on roots and the succulent leaves of aquatic plants. Its total length, including the tail, would be nearly eight feet; its skin was probably either naked or covered with smooth hair like the otter; its ears were no doubt short, and its whole appearance must have been that of an animal fitted to inhabit and seek its food in water. By far the most remarkable peculiarity in this species is the tail, which was composed of nearly thirty vertebræ, and equalled, if it did not surpass, the length of its body. Cuvier has observed that no living animal, with the exception of the kangaroo, has so long and so powerful a tail.

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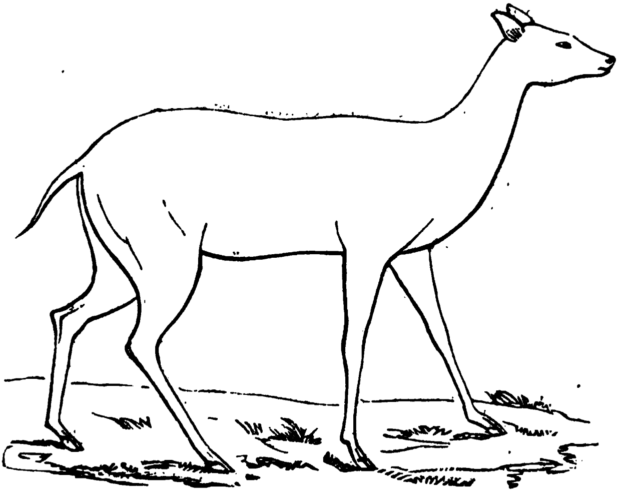
[*] Ανα (*ana*,) privative; οπλος (*oplos*.) a weapon; θηριον (*therion*,) a beast: an animal without defensive or offensive weapons, (having no tusks.)

The species characteristic of the second group of Anoplotheres, Called *Xiphodon* (see fig. 124,) was very different,

Fig. 124



ANOPLOTHERIAN ANIMAL.
(*Xiphodon.*)

both in its proportions, its size, and its habits, from the more common species just described. It is called *gracile*, or slender, as an indication of its superior agility and slender proportions; and, indeed, the graceful elegance of the bones of its skeleton reminds one more of the structure of the gazelle than of any other quadruped. Its height was about as large as that of a goat, but its head and trunk would indicate a much smaller animal, as the bones of the extremities were excessively elongated, and in striking contrast to the species first described. Light and elegant as the gazelle, it would course rapidly along on the banks of the lakes and rivers, or on the borders of those marshes in which the former species lived, and would feed on the aromatic herbs, and browse on the young shoots and tender buds of shrubs growing in such localities. Its movements would be free and unincumbered; and, like most of the more active Herbivora, it was doubtless a timid animal, and provided with large and very mobile ears, readily turned in any direction at the slightest approach of danger. There can be little doubt, too, that it was covered by very short hair, and that in all external characters it resembled closely the ruminants (such as the smaller deer,) and could hardly have been distinguished from them.

The third group of Anoplotheres contains several species much smaller than either of those just described, one of which resembled the hare, not only in dimensions but also in the proportions of its limbs, which are so contrived as to have given it great swiftness of motion, and therefore a means of escape from its enemies. If the Xiphodon was the roe of the antediluvian world, and, from the almost total absence of true ruminants, it is not impossible that the place of the deer tribe was occupied by the pachyderms, this little species represented in the same way the smaller rodents, such as the hare and the rabbit.

It is interesting and curious to find that there is another small pachyderm, whose remains have been found in the

London clay, but which belongs to a distinct genus, still more closely resembling the hare, and was even provided with the large full eye so strikingly characteristic of that timid quadruped. This genus approaches also very closely to another from the Paris Basin, and both of them resemble a small quadruped called hyrax, a native of Africa, and some parts of Asia, more than any other existing pachyderm.

Having now considered in detail these various groups, let us next attempt to group together the principal geological observations of the early tertiary period in Europe. In doing so it may be noticed, first, that at this time all the great plains of Europe and the districts through which the principal rivers now run were then probably submerged; and that in all probability the land chiefly extended in an east and west direction, far out in the Atlantic, possibly even trending greatly to the south and connecting the western shores of England with the western islands of Africa. The land now forming the great mountain chains intersecting Europe, the Pyrenees, the Alps, the Appenines, the mountains of Greece, the mountains of Bohemia, and the Carpathians, existed then only as chains of islands in an open sea. Elevatory movements, having an east and west direction, had already commenced, and were producing important results, laying bare the Wealden district in the south-east of England. The southern and central European district and parts of western Asia, were then the recipients of calcareous deposits (chiefly of Foraminifera,) forming in deep water what is now the Appenine limestone, while the numerous islands were gradually lifted above the sea level, and fragments of disturbed and fractured rock were washed upon the neighbouring shallows or coast-line, forming beds of gravel which form the first covering of the chalk, whereever it has received other older tertiary deposits. The beds of nummulites and miliolites contemporaneous with those containing the Sheppey plants, and the Paris quadrupeds, seem to indicate a deep sea at no great distance, and prove that there were frequent alternations from the deep sea to a coast-line, perhaps the result of disturbances acting in the direction already alluded to.

The shores of the islands or of the tract of main land then existing were apparently low and swampy, rivers bringing down mud in what is now the south-east of England and the neighbourhood of Brussels, but extensive calcareous beds near Paris. Deep inlets of the sea, estuaries, and the shifting mouths of a river, were also affected by numerous alterations of level not sufficient to destroy, but powerful enough to modify the animal and vegetable species then existing; and these movements were continued for a long time. The seas were tenanted by sharks, gigantic rays, and many other fishes of warm latitudes, and abounded also with large carnivorous mollusca, capable of living either in fresh or brackish water. The shelving land was clothed with rich tropical vegetation to the water's edge, presenting to view the palm and the cocoa-nut, besides many of those trees which now lend a charm to the Spice Islands of the Indian seas. All these abounded also with indications of animal life.

The large rivers were peopled with crocodiles; turtles and tortoises floated upon them; and these tenants of the water, strange and varied as they were, and unlike the present inhabitants of the district, were not without resemblance to many species still met with on the earth.

The interior of the land, of which the surrounding waters were thus peopled, was no less remarkable, and exhibited appearances equally instructive. Troops of monkeys might be seen skipping lightly from branch to branch in the various trees, or heard mowing and chattering and howling in the deep recesses of the forest. Of the birds, some clothed in plumage of almost tropical brilliancy, were busy in the forests, while others, such as the vulture, hovered over the spots where death had been busy. Gigantic serpents might have been seen insidiously watching their prey. Other serpents in gaudy dress were darting upon the smaller quadrupeds and birds, and insects glittered brightly in the sun. All these indications of life and activity existed, and that, too, not far distant from the spots on which are placed the two most important cities in the world. But this happened not only before our island was visited by its earliest human discoverer, but long before man had been introduced on the earth.

Not less strange, however, than those already alluded to, were the other inhabitants. With the monkeys were associated small opossums, squirrels, a racoon, and other animals at that time the tenants of the forest. Several of the smaller Carnivora prowled about preying upon these, and amongst whom, a species of fox and a wolf show, that, as there was a large supply of animal food, so there were other animals to avail themselves of the supply. But in all this one thing is remarkable; it is the almost total absence of the tribe of ruminants. None of those which are so useful and almost necessary to man were then to be seen. The deer tribe and the goat, the sheep, the ox, the camel, all are wanting, and their place was filled by various representatives belonging to the tribe of which the hog, the horse, the rhinoceros, and the elephant, are the present types. These, indeed, were abundant and varied enough, both in their dimensions, their appearance, and their habits. Some swam in the water; some tripped lightly and elegantly on the borders of the marshes; others, constantly on the alert, ran like the wind at the slightest approach of danger, or were watching that they might escape by flight or concealment the fate that attended them. Every thing was thus perfectly adapted to animal wants and necessities, but no preparation was yet made for man. Quadrupeds had taken the place once held by reptiles, and include herbivorous as well as carnivorous forms, and so far an advance seems to be indicated, but the destructive races still preponderated in point of numbers and importance.

Such seems to have been the condition of things at this early tertiary period, as far as is made known by geological investigations in Europe, and thus grand seems to have been the first development of the higher types of animal existence if, indeed, our ignorance of more ancient tracts of widely extended land may not have led us falsely to the conclusion that true mammalian quadrupeds were only abundant during the last epoch of the earth's history.

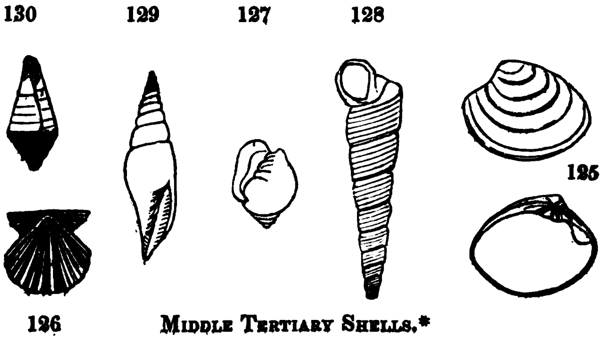
CHAPTER XIII.

THE CONDITION OF EUROPE AFTER THE OLDER TERTIARY BEDS HAD BEEN DEPOSITED, BUT PREVIOUS TO THE HISTORIC PERIOD.

The great series of modifications of the surface affecting Europe, of which the commencement has been described in the last chapter, continued at intervals through a very long period, marked by successive changes in animal and vegetable organization, until at length we reach to the existing creation. Looking, however, at the most recent conclusions of palæontologists concerning tertiary formations generally in the old continents, there does not appear any probability of a true subdivision of those beds into distinct periods, nor does there seem any proof of more than a mere local grouping of the various parts. The whole of the tertiary geology in Europe may certainly be regarded as continuous; and perhaps it would be found that all the other epochs were in the same way really unbroken, if we were in possession of materials enabling us to observe with accuracy the mutual bearing and influence of each part upon the whole development throughout all time.

We left off in the last chapter with an account of deposits chiefly in the vicinity of London and Paris, but reaching also on the one side to the capital of Belgium, and on the other to the south flanks of a portion of the Alps, and the eastern part of the Mediterranean. There can be little question that throughout the whole of Europe the general change of level, the commencement of which is thus marked, was such as to produce elevation on a grand scale, but it was long before this elevation was sufficient to raise above the waters the great plains of our continent, or those districts watered by its principal rivers. These, indeed, were the recipients of the great mass of the deposits then going on; and it is not unlikely that the very fact of reiterated changes of level may have rendered the amount of material thus removed very considerable.

The great valleys of the Loire and the Garonne in France; the tract between the High Alps and the Jura mountains in Switzerland; the tract north of the Alps extending eastwards in the present valley of the Danube towards Turkey, and as far as Hungary, and then northwards into Poland; the tract, also, north of the Alps extending in the Rhine valley as far as Mayence, and occupying a breadth of many leagues; the eastern coast of England, the western coast of the Spanish peninsula, and the south of France, —all these districts are marked by deposits, for the most part more recent than the London and Paris beds, but more ancient than the great south Italian series, and distinctly separated from the cavern and gravel deposits, which ap-



MIDDLE TERTIARY SHELLS.*

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* 125, Venus. 126, Pecten. 127, Auricula. 128, Turritella. 129, Mitra. 130, Conus.

pear to be among the newest of the geological formations in what is now called Europe. The more remarkable characteristics of this intermediate period, so far as fossils are concerned, must be sought for in the strata of the Rhine valley, where we find some remarkable and interesting zoological facts developed, although on the whole the natural history of the period in question manifestly combines the more ancient character of the older strata with the recent zoology and botany of the same countries at present. Without at all dwelling on the subject of the fossil shells and other Invertebrata of the period, a group of some characteristic forms is given to mark the gradual and peculiar approximation to the existing fauna.

In beds of the middle or newer part of the tertiary epoch, there are also occasionally found numerous remains of reptiles, but these are chiefly confined to forms more or less resembling those of existing nature. Amongst them, however, may be mentioned a gigantic salamander, once thought to be the remains of some human skeleton, and nu-

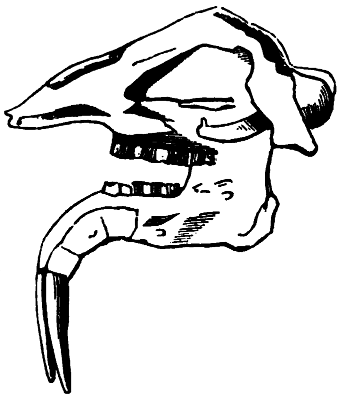
Fig. 131

OENINGEN FRESH-WATER TORTOISE.

merous turtles and tortoises exhibiting marked peculiarities of structure. The beds at Oeningen, in Switzerland, near to the Lake of Constance, offer a rich variety of such forms, and include, also, many very interesting species of fishes, all of which are extinct. The figure annexed (131) represents an interesting chelonian animal from this district.

Of the quadrupeds of this middle period, the *Dinotherium** is in some respects the most remarkable, not only in point of size, but in its relation to the anoplotheroid animals of the older beds on the one hand, and to the elephantine animals of more recent times on the other. The remains of this monster are nowhere common, but have been found both in the Middle Rhine valley (between Mayence and Bâle,) and also in the valleys of the Jura chain.

Fig. 132.



DINOTHERIUM.
(Skull.)

It dwelt, probably, in swamps. Its length was nearly twenty feet; its body, huge and barrel-shaped, very much resembling that of the hippopotamus, being little raised above the ground, although the huge columns which formed its legs are supposed to have been nearly ten feet in length. Its head, rarely, perhaps, brought entirely above the water, was like that of a large elephant, and it was provided with a short, but very muscular and powerful proboscis. A pair of large and long tusks werd appended to this skull, and curve downwards, as in the walrus. But observe the fact most remarkable of all. These tusks do not proceed from the upper jaw, whence they could be made to depend entirely upon the bones of the neck to support them, but are fixed in the lower jaw, and are planted, as it would seem, in this strange position at the greatest possible mechanical disadvantage. There can scarcely be a doubt that an animal provided with appendages so placed was an inhabitant of water; and the tusks, which are very large, were probably useful as pickaxes, enabling the monster to dig for succulent vegetable food by day, while perhaps at night they could be attached like anchors to the banks of the river or lake in which the animal habitually dwelt. It was the most gigantic of the herbivorous quadrupeds, and was associated with the palæotheres of the more ancient tertiary period, and with the mastodons and elephants which lived on till a far more recent date.

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* Δεινος (*deinos*,) fearfully large; Θηριον (*therion*,) a beast.

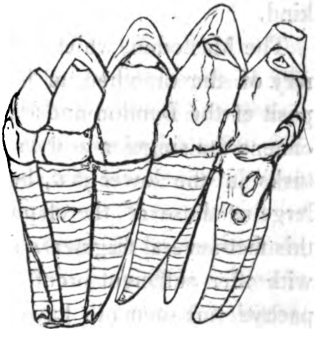
It is not unlikely that at this time, when the palæotherium and the dinotherium were thus companions of the elephant, a large fresh-water lake covered what is now the valley of the Middle Rhine. This supposition involves the existence of tracts of land enclosing such lake, but the direction of the land must have been somewhat different from that now adjacent. An open sea then seems to have extended from the Caspian and Black Seas towards the north-west, quite into the north of Switzerland. The present chain of the Alps was rising and assuming the character of a mountain range, forming, perhaps, islands in this great sea, which must have covered the whole of Italy, Turkey, and Greece, a great part of Asia Minor, and much of northern Africa. The great features of the modern fauna, and even of the flora of these districts, were, however, already in the course of development; the continent of Europe was beginning to assume its general contour; England was, perhaps, already an island, though in that case only recently separated from the main land, to which it was afterwards united; and the pent-up gases, whose efforts to escape were lifting extensive districts above the sea-level, and forming great chains of mountains in north Italy, were partly and at intervals relieved by volcanic eruptions which took place in central France, in north-eastern Spain, and in the Lower Rhine, near the present town of Bonn. Possibly it was also at this time (though the event may have occurred earlier) that the great submarine flow of melted rock took place, whose effects are seen in the north-east of Ireland and the opposite islands of Scotland, where the chalk is covered by this erupted matter. The picturesque basaltic columns of the Giant's Causeway and Staffa mark the extent and intensity of a line of volcanic action, which has long ceased to produce direct results in the British islands.

After the lapse of a certain period, and when the elevatory movements had long gone on, the continent of Europe was at length fully brought above the surface of the sea, and became a fit habitation for the land animals of various kinds gradually introduced upon it. The deep and broad inlets of the sea became valleys and plains; the lakes were drained by the great river channels, which, owing to the greater elevation of the interior, conveyed the water in a definite and short course to the sea, instead of allowing it to stagnate over wide tracts of low swampy land; and the whole Continent put on its present aspect.

But during these changes the climate had also become greatly modified. The increased proportion of land, especially towards the north, would necessarily lower the general temperature, and at the same time render the climate more excessive. Vast forests, composed of oak and beech and other modern trees, produced other and not unimportant modifications; and at this period, probably before the great expanse of land towards the North Pole had arisen from the sea, and while the general character of the great European tract was still insular, vegetation extended almost to the Arctic Circle, and to such an extent as to provide food and shelter for the largest quadrupeds. This combination of analogies and differences forms throughout a somewhat striking character of the middle period, and we find, as one result, that the physiognomy of the fauna at present obtaining in northern Europe, is closely allied to, though not identical with, that which formerly characterized the great plains of Siberia, and corresponding tracts of North America.

At this period the most gigantic of the existing groups of vegetable-feeding quadrupeds seem to have been represented by very nearly allied species, roaming at will from the latitude of Italy to the North Pole, and over the whole of the land in the northern hemisphere. These animals were apparently organized so as to be in some measure sheltered from cold, the elephants, for example, having been covered with hair. The species include a multitude of animals bearing a greater or less resemblance to the present inhabitants of the respective districts, but most of them not now met with in a living state. Among the animals of this kind now certainly extinct must be ranked several species of elephants and the Mastodon.

Fig. 133



MASTODON.
(Grinding Tooth.)

This latter animal whose mammillated teeth have long been known, grew to about the same size as the elephant, being even perhaps occasionally somewhat larger, but its body was longer in proportion, its limbs thicker and shorter, its mouth broader, and it appears to have formed a link in the chain connecting the elephant through the dinotherium with the tapir. In North America this animal was widely distributed, and perfect skeletons of it have been obtained from the great salt-marshes in that country (often many acres in extent,) the animal appearing to have resorted thither for the sake of the salt, and becoming occasionally mired, as large heavy quadrupeds frequently are at the present day. The magnitude of the North American swamps or quagmires, one of which extends for forty miles in a north and south direction, with an occasional breadth of twenty-five miles, renders it probable that some of the more ancient deposits in which the remains of land animals occur, in a similarly perfect state, may also have been of this kind.

The Mastodon, which with the elephant was a contemporary of the dinotherium in the period succeeding the deposit of the London and Paris beds, exhibits in some specimens the singular and interesting phenomenon of small tusks in the lower jaw, besides fully developed tusks, as large as those of the elephant, in the upper jaw; and of this fact several fragments of the animal that have been met with offer sufficient proof. Each group of these gigantic pachyderms seems to have been very widely spread during the period immediately subsequent to its introduction; and we meet with the remains of a vast number of individuals not only in Europe but in Asia, while the Mastodon and elephant also extended into North and South America, and even into the great island-continent of Australia.

The actual period at which the dinotherium and Mastodon became extinct has not yet been fully determined; but there seems no doubt that the latter genus, as it was more widely spread in space, had also an extended range in time; and, as we have already had occasion to notice, it seems to have connected the middle with the newer series of deposits, possibly reaching down almost to the human period, and certainly in the latter part of its course being accompanied by species which are now existing, both of the larger pachyderms, and also of the smaller animals of various kinds.

It was conjectured by Cuvier that the mastodons were more aquatic in their habits, and were better adapted for swamps and marshes, than the elephants are known to be; but this the form and structure of their teeth renders improbable, and they most probably fed on tough vegetable food, such as the branches of those trees common in the temperate zone, and even on harder and coarser substances than those which the teeth of the elephant are enabled to grind to pulp.

Widely as the Mastodon was once diffused over the earth,—and its remains are met with in the tropics and in both temperate zones, and have been found in America up to the 66th degree of north latitude,—we still have no difficulty in fixing upon its metropolis, since in the north temperate zone, in the western hemisphere, these remains are found to outnumber those of all other large quadrupeds, and bear to the bones of elephants the proportion of five to one. The magnificent and complete skeleton of a Mastodon from the banks of the Missouri, now in the British Museum, is an instance of the condition of preservation in which organic remains of extinct species may sometimes be presented for the examination of the naturalist, and offers an admirable opportunity for making out all the peculiarities of structure. We shall see, hereafter, that, if such magnificent examples are not found in the deposits of northern India, it is rather owing to the condition of the beds in which fossils are preserved than from any want of abundance and variety in the species.

The elephant has been mentioned as the companion of the Mastodon in Europe during the middle tertiary period, but the animals of this kind were also accompanied by a vast multitude of others, whose remains have been chiefly found in the beds of the valley of the Upper Rhine between Mayence and Bâle. During the period thus represented, and while a portion of the "crag" on the eastern coast of England was being gradually added to the tertiary accumulations of our island, a gradual elevation was taking place in most parts of central Europe, in northern Asia, and in North America, modifying the form of the land in the northern hemisphere, impressing upon it those peculiar characters which it now presents, altering also the climate, and rendering it more excessive. Up to this time, however, the Arctic ice had probably nowhere extended beyond the Arctic Circle, and was perhaps limited to a range far within that area. Beyond the 70th or 75th parallel of north latitude the warm summers then seem to have so far preponderated over the cold of winter as to allow of the presence of vegetation in spots which are at present bare and desolate, the frozen soil now yielding only a few lichens, and vegetable life being often limited to the little blood-like particles spotting the surface of the snow.

The middle tertiary period, whose gigantic pachyderms unite such distant quarters of the globe, is, after all, but poorly represented by fossils in Europe, except in the valley of the Rhine. But we have good proof of changes then going on which mark the lapse of a long series of ages; and it is most likely that during this period nearly the whole Alpine chain of Europe, and the great range of the Caucasus, attained considerable elevation, while vast masses of sand and other deposited matter were accumulated in the neighbouring seas in those parts of the continent now known as the great valley of Switzerland and the valley of the Danube. The volcanoes of central France, of the north-east of Spain, and of the lower Rhine and the Eifel, were still in full action; a great part of the Continent was in process of elevation; much of the older transported matter called gravel and boulder clay, and many of the erratic blocks, were already covering up some of the more regularly deposited strata; and icebergs, detached from the shores of a polar sea, were now floated down from high latitudes by marine currents, and bore with them fragments of rock, the abundant presence of which, when broken into small pieces, and mixed together, has proved so great a puzzle to Geologists. Perhaps, too, great waves, produced by the sudden elevation of extensive tracts of the sea-bottom, then washed over the low lands with unusual violence, tearing up as they advanced every interposed object, and, after conveying the broken rocks for a short distance, leaving them in heaps at the mercy of the next of the great waves of the same kind that might sweep by in consequence of another upheaval.

During this time the land was becoming peopled with all that rich variety of mammalian life, which characterized the later tertiary periods in the northern hemisphere. In addition to the elephant and Mastodon, the latter of which soon died out, we have two distinct and well-marked species of rhinoceros, a hippopotamus, several kinds of horses, large insectivorous animals, and a considerable number of Carnivora, some of large size, and differing considerably from the groups now inhabiting these parts of the world. We also find an important and very interesting group of true ruminants, including a gigantic deer, and the aurochs, the parent, it would seem, of the tribe of domestic cattle. With these are associated marine Mammalia in great variety, forming, on the whole, a singular and well-marked group, interesting in the highest degree for the analogies it exhibits with widely-spread existing species, as well as for the differences presented between it and any neighbouring fauna.

In order, however, to give an idea of the nature of the species thus forming the inhabitants of northern Europe, England, northern Asia, and part of North America (for we cannot disconnect the latter geological history of this wide tract, including the greater part of the land in the whole northern hemisphere,) we must first trace the conditions under which the most remarkable extinct forms of animal life are presented.

Among the more singular and unexpected localities for fossils of this kind, may be quoted two, very different in every other respect, but both yielding an abundant supply. These are, first, the gravel cliffs at the mouth of the rivers and on the shores of the Polar seas, where the ice has bound together, as with cement, the bones of the ancient inhabitants of those inhospitable climates; and, secondly, the numerous caverns in limestone rocks, common in the mountain limestone of England, Belgium, and France, and the oolitic limestone of the north of Bavaria and Saxony.* These caverns have served as the dens of the animals now entombed there; and we meet occasionally with series of bones belonging to some carnivorous species, exhibiting a long succession of generations, and associated with remains of other animals upon whom these Carnivora preyed.

Besides the frozen shores of Siberia, and the caverns of England and Europe, the actual gravel spread over a large extent of surface in northern Europe and England also abounds with fragments of large animals, amongst which the remains of elephants are especially abundant. The marly beds of alluvium in Ireland and the Isle of Man, the mass of clay and rolled material called "brown clay," in the east of England, and some other alluvial and diluvial deposits, also contain, more or less commonly, fragments of the ancient inhabitants of the land, and amongst these especially occur the remains of the larger pachyderms and ruminants, which were once common.

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* Similar caverns containing bones are met with in limestone in the Brazils, in Eastern Australia, and in other parts of the world.

The conditions under which the animal remains have been preserved in the ice are highly favourable, and they enable us to judge of much more than the mere skeleton of the animal. The preserving power of cold, by checking and for the time preventing decomposition, enables even the muscular tissue to be retained unaltered, so that we have occasionally the skeleton clothed with flesh and skin, as if the animal had died but yesterday, and as if we could yet consider it as belonging to a living race. It is singular thus to find the most perfect monuments of past ages entombed in ice, buried in the silent sepulchre before death had altered a single character of structure, and now from time to time disinterred and seized as prey by the present denizens of those climates, the wolves, the dogs, the foxes, and the bears, or rescued only from the fangs of such assailants to be the subject of wondering examination by man—their successor, after countless years, in the possession of the earth.

There cannot be a question that many of the larger animals whose remains occur in the gravel of England once ranged over the northern continent as far as the 130th degree of east longitude, and were enabled to live either constantly or migrating southwards during the long winter and returning again in the summer, as far north as the 73rd or 74th degree of latitude. Among the species thus known may be mentioned an elephant and a rhinoceros, but many others certainly accompanied these.

It will be interesting to consider the condition of animals thus embalmed, and the adaptation they exhibit to the circumstances under which they existed; but, before describing the animals and the state in which they were found, it is important to record the fact, that in the same districts, and beyond the 75th degree of latitude, large and complete birch-trees are now found embedded in the sandy cliffs, and are sufficiently plentiful to be used as fuel by the inhabitants. And although, on digging them up, they appear to have undergone decay, and only emit a glow without distinctly burning, yet they have generally retained their bark, branches and roots. The first living trees of the same kind are found about 3° farther south, but are then only shrubs, and do not attain any considerable magnitude till we reach much warmer climates.

The bones and tusks are most perfect and are also most abundant in these districts, when obtained from clay hills or black earth, at a depth of a few feet beneath the surface; and experience has shown, that the more solid the clay, the better are the bones preserved. It is curious, also, that a greater number are found in elevations near the higher hills than along the low coast, some of those hills which are exceedingly prolific being as much as 200 feet above the sea-level. The sand which contains the fossils is frozen as hard as a rock; but an outside layer occasionally thaws, and this being gradually undermined by the water, causes large fragments (consisting of frozen sand and bone) to break off and fall into the stream.

The bones and tusks of the elephantine animals thus found are said to be less large and heavy as we advance towards the north, but increase wonderfully in abundance. For about a century the fur hunters have every year brought away large cargoes from the Lachow Islands, but there is as yet no perceptible diminution of the stock. Besides being more plentiful, the tusks on the islands are observed to be fresher and whiter than those on the main land; and a sand-bank on the western side of one of them proved, on one occasion, a most productive spot, the sea, after a long continuance of easterly winds, washing an abundant supply of bones on the bank, as if from some vast submarine store.

In the latter part of the summer of 1799, a native Tungusian fisherman, who was in the habit of collecting tusks for sale from among the blocks of ice and rubbish which had fallen from the cliffs, saw on the banks of Lake Oncoul, near the mouth of the Lena river, and projecting from the cliff, a mass of unusual form, but, from its shapeless appearance, he could make nothing of it. The year after, proceeding to his usual haunt, he noticed that this lump was somewhat disengaged and had two projecting parts; and towards the end of the summer of 1801, when he again looked at it, he found it to consist of the whole side of a gigantic animal having large tusks, one of which projected from the ice. So slowly do changes take place in these districts, that the next summer being rather cold, no alteration was to be noted; but in 1803 part of the ice between the earth and the monstrous animal was somewhat more melted than before, till the whole at length fell by its own weight on a bank of sand. Next year our fisherman came in the month of March, and cut off the tusks, which he soon sold for about the value of 50 roubles, (about 7*l.* 10*s.*) Two years after this, in 1806, being the seventh year from the discovery of the carcase, these distant and desert regions were traversed by Mr. Adams, an *employé* of the Court of Russia; and his account of the rest of the history of this mammoth, the ancient elephant of northern Europe, is too interesting to be abridged, without the loss of much of its value as a vivid description of so extraordinary a phenomenon.

Mr. Adams states, "At this time I found the mammoth still in the same place, but altogether mutilated. The prejudices being dissipated in consequence of the Tungusian (who had fallen sick from alarm on first hearing of the discovery, because it was considered a bad omen) having recovered his health, there was no obstacle to prevent approach to the carcase. The proprietor was contented with his profit for the tusks, and the Jakutski of the neighbourhood had cut off the flesh, with which they fed their dogs; during the scarcity, wild beasts, such as white bears, wolves, wolverines, and foxes, also fed upon it, and the traces of their footsteps were seen around. The skeleton, almost entirely cleared of its flesh, remained whole, with the exception of one fore-leg. The head was covered with a dry skin; one of the ears, well preserved, was furnished with a tuft of hairs. All these parts have necessarily been injured in transporting them a distance of 7330 miles, (to St. Petersburgh,) but the eyes have been preserved, and the pupil of one can still be distinguished.

"The mammoth was a male, with a long mane on the neck. The tail and proboscis were not preserved. The skin, of which I possess three-fourths, is of a dark grey colour, covered with reddish wool, and black hairs; but the dampness of the spot, where it had lain so long, had in some degree destroyed the hair. The entire carcase, of which I collected the bones on the spot, was nine feet four inches high and sixteen feet four inches long, without including the tusks, which measured nine feet six inches along the curve. The distance from the base or root of the tusk to the point is three feet seven inches. The two tusks together weighed three hundred and sixty pounds English weight, and the head alone four hundred and fourteen pounds. The skin was of such weight, that it required ten persons to transport it to the shore; and after having cleared the ground, upwards of thirty-six pounds of hair was collected, which the white bears had trodden in while devouring the flesh."

A part of the hair of this animal is in the Museum of the Royal College of Surgeons of London. It consists of two sorts, common hair and bristles; and of each there are several varieties, differing in length and thickness. That remaining fixed in the skin is thick-set and crisply curled; and it is interspersed with a few bristles about three inches long, of a dark reddish colour. Among the separate parcels of hair, are some rather redder than the short hair just mentioned, about four inches long, and some bristles, nearly black, much thicker than horse-hair, and from twelve to eighteen inches long.

Thus, then, we find that the elephant of the north temperate and Arctic zone was in most respects exceedingly like the species now inhabiting India, and with the exception of a warm woolly and hairy covering offered but little modification of structure. It was said by the native who discovered the carcase, that it had been so loaded with fat, that the belly hung down below the joints of the knees. The food of the creature was probably twigs and the branches of trees; and herds of these gigantic quadrupeds may possibly have migrated northwards in warm weather to the limits of arboreal vegetation, where from time to time individuals were buried either alive, or soon after death, in an icy shroud, and where the bones of those who died from natural or violent causes were also buried and preserved in the frozen gravel.

Twenty years before the elephant just described was obtained from its icy grave, another carcase, also of a gigantic thick-skinned animal, was found half buried in frozen sand on the shores of the same icy seas. This animal was nearly twelve feet long; its body was clothed with skin, which resembled leather, but was so far decomposed that the discoverers were unable to bring away more than the head and feet. The skin of the head was found to have preserved all its exterior structure, and one could see upon it many short hairs. The eye-lids and eye-lashes had not entirely fallen into decay; a substance existed in the cavity of the skull, and beneath the skin were, in some places the remains of the putrified flesh. It was known at once to be a rhinoceros, by the situation of the horn and the fold of the integument which surrounded it: the horn itself was absent.

In this example the individual belonged to a species exceedingly different in many respects, especially in the form of the head, from the only known existing species of rhinoceros, and the interest is even greater than in the former case, because the differences are more striking. The hair (a characteristic part) was short on the face, and strongly planted in pores of the skin; it grew there in tufts, was of a rigid texture and grey colour, with here and there a black hair longer and stiffer than the rest. The hairs also adhered to many parts of the skin of the legs, being from one to three lines long, and of a dirty ash-colour; they were much more abundant than is ever seen on the living species. It is not to be inferred, from the thinness of this hairy covering of the legs, that the body was also sparingly clothed, since other wool-covered Arctic animals, as, for instance, the musk-ox, are similarly bare on the extremities.

The extinct rhinoceros, thus discovered in Siberia, was like the elephant, widely distributed over the northern hemisphere, at least through the eastern continent, and extended as far as our own island. Its hide was destitute of the folds which characterize that part in the existing one-horned species. One horn, probably the one planted on the bones of the nose, has been found, and is of very large size, measuring nearly three feet in length; and there was probably another behind it,—both of them longer and more formidable weapons than are found in any of the known existing species. The head of the extinct animal was also longer in proportion, and terminated by a very strong bony apparatus, well shown in some of the skulls that have been preserved.

The teeth of this animal prove that its habits, with regard to food, were not very different from those of the recent species; and probably those individuals whose remains are found imbedded in the Polar ice, were in the habit of migrating from the south during the short Arctic summer, and either died from natural causes, or being overtaken by the sudden and intense cold, were prevented from returning. This is the more probable, since, in addition to the animals already described, many others, and amongst them the large bear and the musk-ox of the Arctic land, are known to occur; and the migratory habits of the latter animal have been distinctly noticed by good naturalists.

The large animals formerly spread over such extensive tracts in northern Europe, found in the frozen gravel and sand on the shores of the Polar seas and in the drift-gravel, and often associated with large boulders in warmer latitudes, have also been in many cases preserved in caverns, in limestone rocks, or in the alluvial deposits of lakes and rivers. We obtain also from these sources a knowledge of many species, not hitherto met with in so perfect a state as the elephant and rhinoceros just described, but still affording sufficient material to enable us to determine their general structure, external form, and habits. Among the most interesting of these, from their size and the circumstances under which they occur, may be ranked the great cavern bear, the cavern hyæna, a gigantic feline animal of the caverns, a gigantic animal of the Bos tribe, and a very large horned cervine animal, often designated as the Irish elk. Remains of all these, and also of the hippopotamus and other pachyderms, have been met with in more or less abundance in the caverns, and are mixed with the drift and other gravel of our own country.

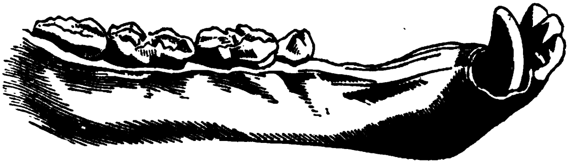
The history of these caverns is almost as curious and interesting, and is as important in a geological sense, as that of the animal remains found in them. They are often at a considerable elevation, the opening being on the side of the valley. On being first broken into they are generally found coated entirely with an incrustation of carbonate of lime, deposited from water that has filtered in from the limestone rock. The floor of the cave is thus hard, and gives no indication of the fossil riches buried beneath it; and even where no stalagmitic incrustation exists, the true ancient floor is covered with a thick sediment of soft mud and loam. The general level of the districts in which the caverns occur has, probably, in most such cases, undergone slow recent elevation without disturbance.

In one of the most remarkable of these caves (Kirkdale, in Yorkshire,) the appearance, when the mud was removed, is described as resembling the floor of a dog-kennel, being strewed all over from one end to the other with hundreds of teeth and bones of various kinds of animals. These fragments were in greatest abundance near the mouth, that part being the most capacious; but the bones of all kinds of animals were strewed quite irregularly.

The caverns thus filled with various bones were in many cases the ancient dwelling-places of large Carnivora, such as the hyæna, the lion, the tiger, and the bear: to these spots the temporary owners had brought their prey to devour in secret; here they lived and died, often from generation to generation, and in these spots we find, written in no obscure language, a portion of the early history of our island after it had acquired its present form, while it was clothed with vegetation, and when its plains and forests were peopled by many of the species which still exist there; but when there also dwelt upon it large carnivorous animals prowling about in the forests by night, and retiring by day to these natural dens.

In our own island the nature of the more abundant bones and teeth, the condition of the bones of the neck, and various other causes, tend to prove that a large species of hyæna, more nearly allied to the South African species than to that of Egypt and Asia Minor, but still very distinct, was the almost exclusive tenant of these caverns. Some of them, however, and by far the greater number of the very similar caverns on the Continent, were occupied by a large species of bear, equalling, or even exceeding in size, the grisly bear (*Ursus ferox*,) and well known to fossil collectors under the name of *Ursus spelæus*, or cavern bear.

Fig. 134



JAW OF CAVERN BEAR.
(*Ursus spelæus.*)

The great cavern hyæna belongs to a tribe now confined to warmer climates; and, while exhibiting all the peculiarities of structure belonging to its genus, this fossil animal was much larger and more formidable than either of the nearest allied species, both of which are inhabitants of the

Cape of Good Hope. Like the living hyænas, there can be no doubt that the extinct species fed on any kind of animal food, living or dead, that came within their grasp. They obtained their prey chiefly or entirely at night; their teeth were exceedingly strong, terminated with blunted cones, and provided with a strong bony belt defending the gum (figures 135, 136.) They were thus especially adapted for breaking and gnawing bones. The strength of the jaws and teeth, and the state of the muscular apparatus for working them, was unusually great even for carnivorous animals; the neck was compact and powerful, and the whole structure bespeaks the greatest possible amount of strength. It is a remarkable and interesting fact, and one which distinctly shows the correctness of the conclusion with regard to the occupation of the caverns by hyænas, that almost all the bones found in them are gnawed and broken, while those in the gravel are comparatively uninjured. The number of individual hyænas determined from the examination of the cavern bones in England amounted some time ago to nearly three hundred,—a large number, when we consider how few probably of the ancient dens have been broken into and examined, and how large a proportion of these animals would necessarily be obliged to depend upon

Fig. 135

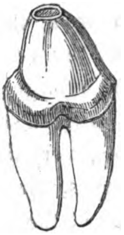
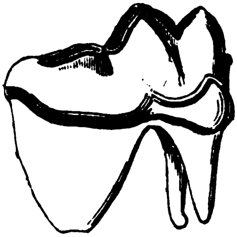


Fig. 136



Teeth of Cavern Hyæna.
(*Hyæna spelæa.*)

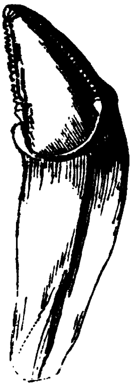
less secure recesses, in those parts of the country where limestone rocks offered no cracks and crevices to serve them as dens.

The hyæna is not strictly a destructive carnivorous animal, although it makes the nearest approach to the true feline character in its teeth. It seeks rather the dead carcase than the living prey, and feeds upon offal in preference to killing for itself. The period at which the large species, just described, was an inhabitant of England, was, however, also marked by the presence of more than one very large species of the true feline tribe, well worthy of notice. Although the animals of this kind are now nearly confined to warm climates, or, at least, are most abundant there, it is by no means the case that there is any peculiarity in their organization limiting them in this respect, and it is certainly rather the abundance of food than the temperature that is concerned in the result. The Indian tiger is well known to follow the great herds of antelopes quite to the verge of perpetual snow in the Himalaya mountains.

The teeth of the fossil tiger of England and northern Europe are at least equal in size to those of the largest Bengal species, and the bones of the extremities are both larger and more powerful; so that this animal was probably even more gigantic than its powerful recent analogue. Perhaps this greater size may have been necessary to cope with the more vigorous and larger ruminants and pachyderms which roamed over the open plains, or inhabited the depths of the forests.

The teeth of a large species of lion, of a true leopard, of a wild cat, and of another remarkable and little known animal, also of large size and highly carnivorous habits, have been found in the gravel and the caverns, associated with those already described. The teeth of this last-named species quite equal in size the corresponding teeth of the tiger,

Fig. 137



TOOTH OF MACHAIRODUS.

and indicate an animal of even greater ferocity. The powerful cutting-tooth, curved backwards like a pruning-knife, and serrated or jagged like a saw, as seen in the annexed figure (137,) is very different from the corresponding structure in the better known *Felidæ*, and the animal has therefore been referred to a new sub-genus, under the name of *Machairodus*.

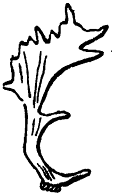
The ruminating quadrupeds contemporary with the animals just described, included several of the deer tribe, a goat, and at least three species of the genus *Bos*. One of the latter is probably identical with the great Lithuanian aurochs, still preserved in eastern Europe; another is a very gigantic species of urus, now most likely extinct; and a third, smaller than the common ox, has been found in the bogs of Ireland, and also in various places in England in the superficial gravel. Of all these, the remains of the aurochs or bison are remarkable for their large size, and their longer and somewhat straighter horns than the existing wild bison, which is a species still preserved in the extensive forests of Lithuania; but still it does not appear that the fossil animal can be separated from that species. The aurochs is distinguished from the domestic breeds by a thicker clothing of hair, and the development of a curly felted mane at the fore part of the body; and it appears to have inhabited northern Europe in company with the other species at the time of the Roman Empire.

It is interesting to find, from the descriptions of Cæsar, that a gigantic aboriginal wild ox (the *Urus*) was known in his time, which was not much inferior to the elephant in size, and which differed from the domestic cattle, not only in its superior dimensions generally, but also in the greater expanse and strength of its horns. Numerous remains of this animal found fossil prove it to have been a contemporary of the elephant, the rhinoceros, the hippopotamus, and the cavern carnivora, at the period immediately preceding the present condition of things. It is most likely that the species has now become absolutely extinct, and that the domestic cattle are rather the descendants of those introduced tame by the Romans, than the degenerate produce of the other more gigantic species.

The small Irish ox is remarkable for the flatness of its forehead and its short and small horns, and may possibly have been the original parent of the mountain breeds of the Highlands and of Wales. Its remains have been found in the gravel, associated with those of the elephant.

The cervine animals inhabiting England and northern Europe, during the last geological period were comparatively numerous in respect of species, and they include many interesting forms. Among the most remarkable is that

138



Fallow Deer.

139

Megaceros.

140

Elk.

which is generally known as the great Irish elk (*Cervus* [*Megaceros*] *hibernicus*;) and the remains of this animal were described so long ago as 1697, but were then referred to the American moose. The Irish deer, however, surpassed the largest elks or wapiti in size, and much exceeded them in the dimensions of the antlers. This character—the vast proportionate size of the horns—which is illustrated in the preceding cut (139,) where they are placed side by side with those of other species of deer, (138, 140,) together with the stronger proportions of the limbs and the great size of the vertebræ of the neck, are modifications which completely distinguish the fossil animal from the moose, and prove it to have been less like that than many of the other deer. In fact, the fallow deer offers the nearest analogies to this extinct and gigantic species.

Several well preserved and perfect skeletons of the Megaceros are now articulated, and may be seen in various public museums; and, although these more perfect remains have been obtained from Ireland and the Isle of Man, where the conditions were highly favourable for their preservation, there is not wanting distinct evidence to prove that the animal was also formerly an inhabitant of England. The expanse of the horns, in some specimens, is said to be as much as sixteen feet; they are branched and palmate, and were unquestionably shed and reproduced annually, like the horns of others of the deer tribe. The specimen in the Museum of the Royal College of Surgeons in London is ten feet six inches high to the summit of the antlers, and six feet to the top of the longest dorsal spine. In this instance the span of the horns is but eight feet, and the weight of the skull and antlers seventy-six pounds; but in other cases, as in the Dublin specimen, the span of the horns as well as the weight is much greater. It is interesting to consider the extent of vital energy which could thus throw out, in the course of three or four months, between sixty and seventy pounds weight of osseous matter.

There is reason to suppose that this animal remained an inhabitant of the earth up to a comparatively late period, though it had probably died out before the introduction of the human race. It must have existed at a time when there was abundance of open forest and an ample supply of vegetable food, and its remains occur chiefly in the marl, but are found also in gravel. There can be little doubt that it, and several of its contemporaries, were destroyed during or in consequence of the great geological changes that have taken place recently in our island, the general result of these having been to diminish the supply of food and shelter required by the large vegetable feeders, which anciently formed a most important part of its inhabitants.

A very large round antlered deer, whose head was of greater size than that of the Megaceros, is found in England to have been contemporaneous with this latter species and with the cavern animals; and with these were also associated the red deer, the rein-deer, and a nearly allied but distinct species of about the same dimensions, the modern fallow deer, and the roebuck.

Lastly, we find, in addition to these land Mammalia, whose remains are common, that there are also indications of the larger marine tribes of the same great natural order. The bones of the extremities and portions of the vertebral column are among the fossils of this kind found in the gravel; and in the cliffs of Suffolk and Norfolk, in the newer and perhaps middle tertiaries, below the gravel, fragments have been found

Fig. 141

WHALE'S EAR-BONE.

which are recognised as ear-bones of cetacean animals of various species and very different size. I annex a figure of one of these.

In tracing the peculiarities of structure and habits of these animals, and in describing as almost contemporaneous those strange and remarkable pachydermatous genera, the Dinotherium, the Palæotherium, the Mastodon, and the elephant: —associated as these are with the equally striking extinct feline animals allied to the lion and tiger, with the hyænas, the numerous herds of gigantic and wild oxen, the large-horned deer and others, many of which are only locally extinct, some now locally abundant, I have hitherto omitted to direct especial attention to the changes that must meanwhile have gone on with regard to the relative level, the extent, and the position of dry land. The picture given of the condition of Europe in this respect at the commencement of the present chapter being referred to, and compared with its present appearance, some idea will, however, be formed of the nature and amount of the modifications that the surface has undergone.

It seems reasonable to assume that the first elevation of great masses of land, some part of which now consists of lofty mountain-peaks of granite and of igneous rocks, should have been accompanied by local disturbances of the bed of the sea, producing waves capable of transporting large quantities of broken rock, and that by a succession of similar movements these fragments might be conveyed, being more and more pounded and rolled, to a distance of many miles, or even hundreds of miles. Perhaps it may be because the quantity of land elevated in the Arctic Circle was lifted up under different circumstances, and in more uniform, dome-shaped, and larger masses, producing more powerful waves, that the fragments broken off from the old rocks of Scandinavia, Lapland, and northern Russia, and the northern parts of our own island (which have all partaken of this movement and its consequences,) have been farther transported, and are deposited in more regular, more widely spread, and more characteristic beds of gravel than the Alpine rocks, whose range is, in every respect, more limited.

The whole subject of the distribution of gravel is, however, one abounding in difficulties which have as yet been only partially explained. Besides assuming the action of great waves acting for a very short time immediately after an earthquake shock, and propelling a mass of broken rock with irresistible power at a rapid rate for a short distance, some geologists have called in the aid of marine currents. The action of the waves on an ordinary coast-line is also itself sufficient to account for many even of the most striking phenomena. While these causes, analogous to those now in action, are thought by some geologists sufficient to explain the facts, others again have resorted to ice in some form as the only agent capable of solving the problem. One theory connected with ice is indeed only more improbable than it is bold and ingenious, its author and supporters assuming the whole of that part of the earth on which gravel is now found to have been once actually beneath a frozen surface, and to have been traversed by glaciers, such as those which in the Alps produce very similar and analogous appearances. There are certainly, however, no sufficient grounds for believing that true glaciers have ever covered Europe, since there is no evidence of the existence of mountain chains from which they could have proceeded.

Although these authors, misled by partial observation, have thus limited the action of ice to glaciers, or frozen streams descending from mountain sides and moving along on the plains, simply from the action of gravitation, or by some supposed force connected with the alternate thawing and freezing of water, others have assumed that the ice may have acted in the form of icebergs. In other words, it has been supposed that glaciers, descending to the sea in cold climates, may have been broken off from time to time and floated away, conveyed by marine currents until they are either melted by the warmer waters of the ocean or stranded on some submarine mud-bank or shoal. In either case, and both are illustrated by recent examples, the load of broken rock which such masses of ice carry would form a bed of gravel, which, on subsequent elevation of the sea bottom, might become a portion of the general surface of a continent or island.

The breaking up of the surface, during or after the intense cold of an Arctic winter, or even of such cold as occurs annually in thickly-inhabited districts in Russia, is another means by which some of the phenomena of gravel when little removed from the parent rock have been explained. Geologists are indebted to Sir Robert Murchison for this and many other ingenious suggestions concerning the origin of gravel; and there can be no question, that the careful examination of existing nature, so far as it is exposed to our view, is the most satisfactory as it is the most safest and most reasonable mode of explaining the various appearances which are presented in the course of geological investigations.

Whatever the cause or causes may have been, the distribution of numerous blocks of stone, sometimes rounded, but more frequently angular, and of every size and shape, and the removal of these to various distances from the parent rock, are facts distinctly made out. Such blocks, also, are not confined to northern Europe, but are met with both in North and South America, and in other parts of the world. It is, however, certain, that true gravel with rolled blocks of stone is not universally distributed; and the effects thus produced have been as partial as they were frequent, the result being often quite different. It thus happens that while in most cases, common gravel, or transported and erratic blocks and boulders, have been deposited, we find elsewhere only great masses of mud and clay, mixed with stones, sand, or any other material, drifted into recesses, and left there by the iceberg or the retiring wave.

It is not likely that a great system of elevation can have acted during a long period, bursting asunder in some districts the hard and brittle rocks at the surface, and sending up granite in a soft and pasty or melted state; tearing asunder in others the tough superficial beds, and allowing the escape of gaseous vapours and currents of molten rock; while in others, again, wide tracts were slowly but permanently lifted above their former level, without a reaction having taken place after the force had ceased to act, causing a general or partial subsidence over some vast areas.[1] Possibly, the more extreme and Arctic temperature which many things seem to indicate as characterizing a late geological period, may have been connected with a more uniform expanse of land near the poles, the general level of that land being also somewhat higher than at present. After this partial elevation there may also have been a partial depression, especially, perhaps, in north-western Europe; the climate there may have become ameliorated, while at the same time considerable tracts, which had long existed as dry land, were gradually covered up by water.

It was probably after this last depression, succeeding the period of deposition of the gravel, and itself accompanied by undulation of the surface admitting of many superficial deposits in certain districts, that the final separation of our own islands, and the destruction of many species of animals which had before been their chief inhabitants, took place. Possibly, also, the land may then have sunk some two or three hundred feet, or even more, below the present level, so that there remained only the higher grounds on which the smaller animals were enabled to live, while the larger ones died out. Another movement of elevation then occurred, once more bringing large tracts of land above the surface, especially along the north-western extremity of Europe and the neighbouring British Islands, and by this were formed the numerous raised beaches of the south and west coast of England. It was not till this late modification of the surface, that the courses of the rivers, the general contour of the land, the general relations of land and sea, the climate, and the general fauna and flora distinctly assumed their present character; nor was it, perhaps, till long after this time, that, on the introduction of man,* new changes and modifications took place, and new races were introduced, not, indeed, naturally indigenous, but otherwise well adapted to the soil and climate. Nor, indeed, is this all; for the same mighty influence has changed even the conditions of climate and the natural course of seasons by the removal of forests and the draining of marshes. In this way have been effected those final, and, in their way, mighty changes, which this closing chapter of the earth's history calls upon us to notice, although, from their recent production, they rather belong to recent natural history than to geology in the general acceptation of the term.

In Europe, and, above all, in England, where every corner of land is considered as waste if it is not employed directly by human agents and for human purposes, and where man is in every thing paramount, these changes have now so far affected the surface of the land, as to render it difficult to pursue our investigations with regard to the true history of unfettered nature. We must go to distant countries and other climes, where nature is still free, to discover the great facts of general progress; it is there, if at all, that we shall find distinct traces of the progress of that well-adapted system, according to which all things, animate and inanimate, work together in harmony; and we must travel with the enterprising and the active, over plains and into forests hitherto untrodden by man, or, with the geologist, we must look far back into the ancient history of the earth, if we would know truly and fully what nature is, and how far the laws originally imposed on matter are real and have been perpetual.

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* There is, however, some evidence tending to prove that man was an inhabitant of our own island even so long ago as the cavern bear and hyæna.

CHAPTER XIV.

THE CONDITION OF INDIA, THE ASIATIC ISLANDS, AUSTRALIA, AND NEW ZEALAND DURING THE TERTIARY PERIOD.

In considering the geology of Europe, we have had to generalize with regard to a district, most parts of which have been mapped with at least sufficient accuracy to enable us to recognise the broad outline of the chief elevatory movements that have taken place, and concerning which we are provided with much minute and detailed knowledge of a positive kind. If, therefore, in spite of these advantages, there is still doubt and hesitation in determining the ancient history and the exact succession of deposits, it may well be supposed that not less difficulty exists with regard to other countries, of whose geological structure we know far less. This is the case with the great continent of Asia, in spite of numerous researches and the labours of many intelligent travellers; and, unfortunately, in many parts, the most difficult of access, especially the Chinese empire, the investigations of these travellers have not included any accurate account of geological phenomena.

With a very few exceptions, the geology of Asia is known only with reference to distant and isolated spots; and this is the case, not perhaps from the want of continuity of such rocks at the surface, but because they are not readily traceable in the districts that have been much visited, and are best developed in those which are least accessible to scientific travellers of the present day.

Generally speaking, however, the continent of Asia, like the greater part of Europe, must be considered as of recent elevation. The broad tracts north of the Himalaya chain, the district marked by the presence of extensive lakes on the European frontiers, a considerable part of the peninsula of India, and probably the whole of Arabia, besides many at least of the larger islands, are marked by the distinct presence of tertiary beds. These, however, exist in a somewhat different condition from that observed in Europe; they often contain fossil remains of animals totally different from European forms, but they still approximate, and offer many interesting analogies on a careful examination and comparison. It would be unsafe at present to suggest what may have been the actual history of the movements that formed the present continent, and the order in which they occurred, but we may at least give some sketch, which, however, it may hereafter need modification, will suggest ideas and assist in the ultimate development of the subject.

If we look at the map of Asia, and compare its physical geography with that of Europe, it will not be difficult to trace the relation of the great mountain chains. The district, whose recent elevation in Europe is marked by the Alps and the Carpathians, is continued into Asia by the mountain chain of the Caucasus, and is thence traceable till we reach the Himalayas. Between these districts are spaces occupied by the Black Sea and the Caspian, where the land has probably only recently emerged from the sea.

Thus, then, it would appear that the elevatory movement has here acted at several places along a band extending for about eight thousand miles, with a breadth of nearly five hundred miles, and running nearly east and west. There is good reason to suppose that the whole of this tract, without exception, was under water at the commencement of the secondary period, for we find beds of lias and various other secondary deposits not only in the Alps and the Caucasus, but also in the western extremity of the Himalayas. The disturbance to whose action are due these two principal ranges of mountain country in the eastern hemisphere, was thus a recent occurrence, geologically speaking; and there is ground for supposing that the carpathians and the Caucasus, which are intermediate ranges between the Alps and the Himalayas, became mountains at even a later date than the Alps.

But the study of Indian geology points still further, and teaches us that the Himalayan movement continued to a very recent period, for we find in the lower ranges on the flanks of this great chain a singular development of upraised and tertiary beds, apparently of various dates. We find, moreover, that the great tract of country overspread by basalt, and appearing to have been only recently elevated, are really of very modern date, and were most likely among the results produced by that vast subterranean action, of which the forcing up, to the height of twenty-five thousand feet, the granite peaks of the mountain chain of central Asia was a direct and striking effect.

The chief localities in Asia which offer distinct and satisfactory evidence on the subject of its ancient inhabitants, are first the entire chain of the sub-Himalayas or Sewalik hills; next the western coast of India, especially near the Gulf of Cambay; and, thirdly, the mouth of the great Irawaddi river, in the peninsula of Siam. These spots are widely distant, but the remains found in each have proved to belong to nearly or absolutely identical species. They are now at very different elevations, the difference amounting to many thousand feet, but they were no doubt formed contemporaneously, and at the same level. These beds are present under different circumstances, the material in which they are embedded varying exceedingly; but they are essentially the same, and appear to have been deposited in a vast inland lake of fresh water, near whose banks there were forests, and in whose waters were present numerous fresh-water fishes.

The remains thus brought to light in the hard sandstone of the Sewalik hills, or in the conglomerate on the shores of the Gulf of Cambay, include a vast number of species, and must have been the result of accumulations made during a very long period, extending over as much of the tertiary epoch as is comprehended in the middle and newer divisions of other countries. They represent the inhabitants of the land during this period, and probably include nearly the whole series, since we find amongst them monkeys, numerous carnivorous animals, rodents or gnawing animals, *Insectivora* or insect-eating animals, and a most remarkable and unusual proportion of pachyderms, the prototypes of the numerous elephants, rhinoceroses, hippopotamuses, horses, &c., whose remains are found in various parts of the northern hemisphere. There is besides a singular and interesting group of ruminants, including giraffes, antelopes, deer of various kinds, and many others more or less resembling the existing animals of the order. Some anomalous species are also met with, extremely different from existing forms; and, in addition to these mammals there are a number of reptiles, amongst which is a tortoise of the most portentous dimensions.

The detailed history of these animals, and the conclusions derived from the careful study of the numerous and perfect remains of them that have been obtained, have not yet been presented to the world by the naturalists best qualified to determine these matters, although the fossils have been the subject of careful study for a long time, and a magnificent work, in which they are described and figured, is now in course of publication.* The account given of them by myself, in a work published in the autumn of 1844,† is still the only general outline on record, and I am obliged therefore to repeat some portion of that in the present chapter.

Of the various animals whose remains are found in these Indian tertiaries, among the most striking, from its shape and proportions, was that designated "Sivatherium."‡ This animal appears to have been as large as the rhinoceros. Its head was even larger in proportion, and was shaped like that of the elephant, being provided with a small trunk or proboscis; the eyes were small and sunk, the head very large in the posterior direction, and the general expression probably dull and heavy. The teeth were rather fitted for bruising and crushing the branches and twigs of trees, than for masticating the more succulent and coarser food of the rhinoceros; but the animal must have had a compound stomach, resembling, in the peculiar and typical habit connected with this structure, the ordinary ruminants, though the habit was not perhaps developed to quite so great an extent.

The most remarkable fact with regard to this animal is connected with another point of structure by which it approximates the ruminating tribe: I mean the possession of horns. Not only was the Sivathere provided with one pair above the brows, but it had another pair placed more towards the back of the head, in the manner observed in some of the four-horned antelopes. In the Sivatherium, however, (unlike the antelope,) one pair of horns resembled those of the cow, and this pair was placed just between and above

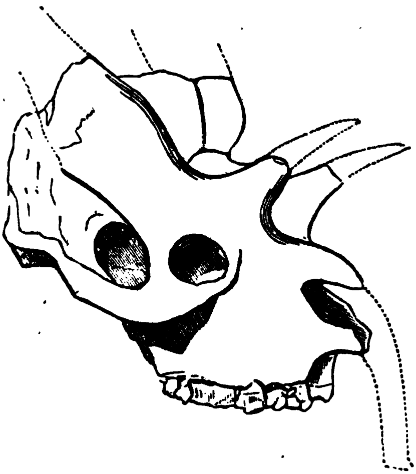
* Fauna Antiqua Sivalensis. By Capt. Cautley and Dr. Falconer.

† Ansted's Geology, Introductory, Descriptive and Practical, vol. ii. pp. 98 *et seq.*

‡ From the Indian god Siva, and θηριον (*therion*,) a beast.

the orbits. The bony cores on which the true horns were placed render it quite certain that the horny sheath must have been of very large size. The other pair of horns were palmated and branching, and resembled rather the horns of the elk than those of any other animal. They also were large and very massive, and were placed behind the pair already described. The form, the proportion, and the singular appendages of the head of this animal, render it extremely interesting as a link between the ruminants and pachyderms; but the nature of the extremities, which were probably of moderate proportions, is still obscure, and requires further elucidation. The fragments of the animal from the Sewalik hills are accompanied by the remains of pachyderms, and are in a very perfect state, but other very nearly allied generic forms have also been found at Perim Island, in the Gulf of Cambay.

Fig. 142



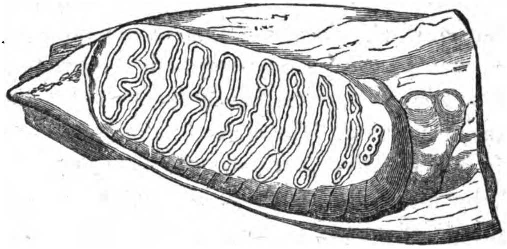
SIVATHERIUM.

Amongst the animals associated with the Sivatherium, there were several pachyderms of large size, including at least seven species of elephants and mastodons, forming an almost perfect species, uniting the whole group of these animals by successive links, two of which, the Asiatic and African species, still exist. There is also a Dinotherium, at least as large as, and probably larger than, the species found in the Rhine valley. There are several species of hippopotamus, some of large, and others of very small size; more than one rhinoceros, distinct from either of the existing forms; several species of the genus *Equus* (horse, ass, and zebra,) varying in size from the ordinary dimensions of the horse to a little creature not larger than the gazelle. To this list may be added also more than one species of giraffe, of somewhat stouter make than the existing species, and of larger size; besides a great multitude of antelopes and deer, and several of the Bos tribe. The Carnivora included a large extinct genus, probably fiercer and more powerful than the tiger, and resembling the Machairodus, already described as occurring with the cavern bones in England and Europe. There were also numerous other feline animals, a colossal bear, and several remains referable to the dog tribe and the hyæna.

All these animals were either associated together at the same period, or succeeded one another in groups occupying the land then existing; but almost the whole of those, whose remains are thus found, have now become extinct. The following figure (143) represents part of the lower jaw and tooth of one of the extinct elephants of this period, and is copied from Capt. Cautley and Dr. Falconer's great work, already referred to.

The great Indian fossil fauna, which lasted so long without any interruption, was thus at length broken up and brought to a definite conclusion, while that of the western districts appears to have only undergone some modification, involving the destruction of the more prominent groups. This, perhaps, was the natural and necessary result of the nature of the changes effected; these changes having altered the original position of the Indian beds to a very great extent, and having been accompanied by the outburst of a larger quantity of melted rock than has been observed in any one district elsewhere on the surface of the globe. Not less than two hundred thousand square miles of country are there entirely covered with basalt of comparatively modern date, and great lines of elevated land also of modern elevation now form lofty and extensive tracts; the Ghauts of south-western as well as those of eastern India, the central or Vindhya range, the northern Circars, and other mountain ranges have all been formed, and vast tertiary deposits, of which the Kunkur and the Regur or cotton soil of India are among the most remarkable, have been spread out over the surface. These, it is probable, are all different results of one system of upheaval, which did not terminate till the elevation of the loftiest mountain tract in the world was effected; and these changes are certainly of comparatively recent date, many of them having gone on even during the

Fig. 143



JAW AND TOOTH OF ELEPHANT.

historic period. Probably much of the low land, and even some of that having considerable elevation in the plains of central Asia, has only at a very recent period emerged from the sea.

India is connected geologically with Europe in very distinct ways: partly by the continuation, at intervals, of the mountain chain of the Himalayas, in which secondary rocks form the central axis; partly by several tertiary or very late secondary districts, extending from Cutch, near the mouth of the Indus, by Arabia, into Egypt; and partly by the very modern alluvial and sandy tracts of the Caspian, passing into Siberia.

Much remains to be made out with regard to all these links, but much also has been done; and there can be little question that the great sandy deserts of Arabia and Africa, and the steppes of Tartary, have been at no very distant period beneath the sea. The continuous volcanic band commencing in Asia Minor, and traceable through the Mediterranean, by the Greek Islands, into south Italy, has also been concerned very intimately with the elevation of the tract both to the north and south of it. We may even hope some day to connect by a perfect series the middle and newer tertiary formations of the old continents in the northern hemisphere; and perhaps the time is not very far distant, when, the Russian and Tartar provinces in northern Asia being surveyed, and some glimpse obtained with regard to the geological structure of China, a complete history may be worked out, defining the limits of change during the tertiary period throughout this vast tract.

In the way of tertiary geology, many parts of Australia appear to promise matter for investigation, as interesting as that of the better and longer known continents, and on almost as grand a scale. At present, however, our knowledge of fossils in this respect is limited to the bones of various quadrupeds, partly obtained from caverns in limestone, and partly from rolled and transported material corresponding with our gravel. There is, on the whole, a great poverty in the number of generic and specific forms in this large tract of land, not only of the fossil remains of the larger land animals, but also with regard to the existing fauna, which as well as that now extinct, is limited to a particular group of animals, all of them exhibiting a peculiar bony apparatus in the pelvis. In the female this is connected with the presence of a pouch, where the young are received at a very early period, and carried about for some time after birth, whence the animals are called marsupials, or pouched animals.* Fossil remains of animals of this kind have been already alluded to, as occurring in the secondary and older tertiary beds of our island.

In Australia, the existing marsupials, or pouched animals, include species having almost every peculiarity of structure and habit; and they are so organized, that, while some are mere vegetable feeders, others are omnivorous, and others again carnivorous. There is doubtless some reason why the animals of this singular continent should be separated by so broad and distinctive a character from those of the rest of the world.†

The fossil animals of Australia are also marsupial, and exhibit forms which, for the most part, are not very different from those still living. Some, indeed, offer peculiarities sufficiently striking, as well in point of size as structure, and of these we may mention two genera, the former being a gigantic wombat, and the latter representing in its proportions the elephantine animals of other continents, but still retaining the marsupial character. The bones that occur in a fossil state are sufficient to indicate many interesting conclusions with regard to the ancient inhabitants of this singular and now detached continent; and, combined with the knowledge we possess of the present and former inhabitants of the existing land in other parts of the world, they lead us to suppose that different orders of the great class of mammalian Vertebrata have been fitted to inhabit, or at least to have been chiefly developed in different countries; and that, while Europe, Asia, and Africa, with the adjacent islands, form one principal district, and are also connected with North America; the recently elevated continent of South America forms another, and Australia a third; but we find that, in the vast tract of land in the northern hemisphere, there is the greatest variety of types, corresponding, it may be, with a more varied character of the land, and the differences of climate thence involved.

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* Of this remarkable group some species are found in the Molucca Islands; and one genus, containing several species, is peculiar to America; and, though chiefly confined to the tropical portions, is met with as far north as the United States, where, however, only a single species is found. The number of species in islands north of Australia (New Guinea, &c.) is probably not inconsiderable.—Waterhouse's "Mammalia," vol. i. pp. 2, 3.

† I have already alluded to the possibility that this character may have reference to the physical geography of the districts inhabited by the group. See *ante*, p. 202.

But Australia is not entirely unconnected zoologically with the northern continents. It contains, in addition to its numerous marsupial animals, one species which is considered to be a true Mastodon. It is thus brought into relation with distant countries by a genus which forms a link between the tribes inhabiting Europe, Asia, and Africa, and North and South America. This fact is the more interesting, since the widely spread and cosmopolitan animal in question seems to have been amongst the last of those mighty tenants of the earth that ceased to exist immediately before man was introduced.

Very few of the islands near Australia, except Van Diemen's Land, and very few indeed of those other islands which form the numerous archipelagos of the eastern and southern seas, are sufficiently well known, or have such an extent of superficial detritus, that we could with any reason expect them to furnish much palæontological evidence. New Zealand is, in point of fact, the only island from which such remains have been obtained; and the condition of the bones, and the circumstances under which they are found, render it impossible to state very decidedly in what bed they there occur. It is, however, something to know that in these islands there existed formerly, and possibly not very long ago, a considerable and important group of wingless birds, of which one representative, the *Apertyx*, still remains, although apparently that also will soon be lost. Many extinct species of these strange animals have been found in the gravel of the northern island, and they vary greatly in size, some having been far larger than the largest ostrich, while others were very small. In all these the general character is nearly the same, the animals being much stouter and more powerful in proportion than the ostrich, and absolutely without any trace of wings. The general outline of one of the largest of these extraordinary animals, of which a figure is given in the annexed wood-cut (fig. 144,) will afford some notion of the vast proportions attained; the figure of a man being drawn to the same scale as the bird, to assist the eye in judging of the dimensions. The various species hitherto determined have all been referred to a single genus, under the name *Dinornis*.* The legs of the Dinornis were powerful, and were no doubt well adapted for rapid locomotion; and in the Apteryx similar powerful extremities enable the animal to run swiftly, and when attacked to defend itself with great vigour. The Apteryx is nocturnal in its habits, and dwells in the deepest recesses of the forest, where gigantic trees are interwoven almost impenetrably with climbing plants, and where, deeply

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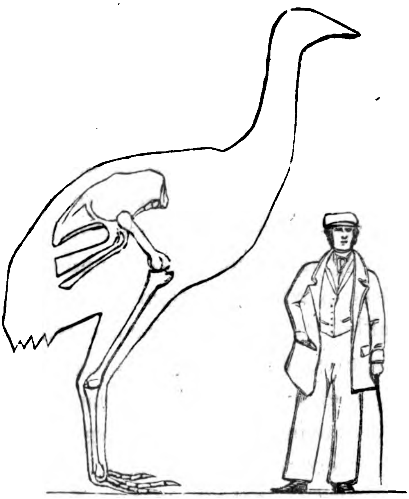
* Δεινος (*deinos*,) enormously large; ορνις (*ornis*,) a bird.

Fig. 144



Dinornis.

embayed in the mountains, there occur open swampy spots covered with bulrushes. It feeds on insects and seeds.

The islands of New Zealand, situated to the east of Australia, are still further removed than that continent from the groups of islands in the Indian Ocean; but, in spite of their distance, it is in these latter that we find the nearest analogue to the singular wingless birds just described. The *Dodo*, which had been brought to England and preserved in museums more than two centuries ago, and figures of which have been given, appears to have inhabited the Mauritius and the island of Bourbon at no distant period, although for some centuries it has not been seen in a living state. Like the extinct wingless birds of New Zealand, it was nearly allied to the cassowary, also an inhabitant of the

Mauritius, but it was more massive, and of more clumsy proportions.

The study of the tertiary geology of Asia, Australia, and the islands of the Pacific and Indian Oceans, assisted by broad general views of the physical geography of those countries, seems to point to them as among the chief districts which have undergone changes during the latest geological period; and there is every reason to conclude that they are still being greatly modified by undulatory movements on a grand scale, constantly going on over a large part of the earth's surface. At the commencement of the tertiary period northern Asia was probably almost entirely under water, and a broad tract of shallow sea may have extended, broken only by a few islands, from the latitude of 50° north to the North Pole. A chain of islands, nearly continuous, may then have existed in what is now the North Pacific Ocean, bringing the islands east and south of the Philippines into close relation with Australia, and with the archipelagos extending many hundred miles to the east of that continent, while Australia may also have then extended westward and northward between the tropics. A considerable part of southern India was no doubt covered by the sea; but land extended probably towards the east and west from central India, perhaps connecting Arabia with the peninsula of Malacca. Within this broad tract of land there appears to have been, during a great part of the tertiary period, a very extensive fresh-water lake, whose northern shore extended within the temperate zone; and on the banks of this lake lived vast herds of the larger Mammalia of all kinds, with those other animals characteristic of the old continent and the tertiaries of India, whose remains are so abundantly distributed in many distant regions. The disturbances which were then in action breaking up the chalk in England and elevating the Weald; those which, advancing eastward, formed hills in the great Alpine countries of Europe; those which also lifted the Caucasus from the sea-bottom, and partly found vent in the now extinct volcanoes of Asia Minor, had not yet disturbed this vast and thickly-peopled district, which was not greatly modified till very late in the tertiary epoch.

The Himalayas, and the mountains which now connect that chain with Persia, were, however, it is probable, even then indicated by a chain of islands, and did not till a much later period become elevated into a mountain range. The sands and other rocks, which, by slight undulations of the surface, had been deposited in great thickness on what are now the flanks of this range, and which received and buried vast multitudes of the bones and other remains of the inhabitants of the land, were then lifted up, and partook both of the main elevatory movement which lifted the plains of India, and of the local disruption which produced the mountain chain.

The elevation which commenced in the Himalayan region did not at once disturb the formation of deposits a little further to the south. These seem to have been continued without interruption far into what may be considered the modern period; and yet, after these, there occurred changes in this part of the world of the most gigantic nature, resulting in the outpouring of vast quantities of lava, and the elevation of the singular chain of the western Ghauts of India. Scarcely any distinctly marine deposits of a late tertiary period have yet been recognised in this part of the world.

These movements, described in so few words, were doubtless going on for many thousands and tens of thousands of revolutions of our planet. They were accompanied also by vast but slow changes of other kinds. The great plains of Tartary, the whole of Siberia, and many parts of north-western Europe, were then undergoing elevation. The inhabitants of a tropical or warm temperate continent extended into these new countries, becoming acclimatised in high northern latitudes; and where we now find only the bear, the wolf, and the fox, the elephant, the rhinoceros, the hippopotamus, and a multitude of feline and other typical carnivorous species, were then fully represented. As, however, the northern land increased in extent, rose in elevation, and advanced further towards the pole, the effects of such change became felt. Intense cold advanced further to the south, the climate of the central districts from insular became extreme and continental, and at length the greater number of the animal inhabitants, unable to exist under such circumstances, gradually, but completely died out.

Meanwhile, we may inquire concerning the fate of the continent, whose position between the tropics has also been indicated. The expansive force employed in lifting up, by mighty movements, the northern part of the continent of Asia, found partial vent, and from numerous subaqueous fissures there were poured out the tabular masses of basalt occurring in central India, while an extensive area of depression in the Indian Ocean, marked by the coral islands of the Laccadives, the Maldives, the great Chagos bank, and some others, were in course of depression by a counteracting movement.

A similar area of depression, on a far grander scale, is also indicated among the western islands of the North Pacific Ocean, and we see distinct proof of great change having been effected in all these districts; involving, indeed, not only depression, but partial and occasional elevation, especially in the line of modern volcanic action extending from Sumatra to New Zealand.

The continental area formerly, it would seem, connecting the island of New Guinea with parts of Australia, and reaching to about 10° N. lat., seems to have sunk down, contemporaneously with the elevation of land in the north temperate zone; and the movement of depression in this case, and of elevation in the other, is most probably not yet completed. During the changes thus going on, it is not easy to conjecture at what rate other and corresponding changes may have affected the organic world, but one series of facts seems distinctly made out, and forms the groundwork on which these conclusions are based. I mean the former distribution of the larger land animals in groups not very dissimilar to those now existing over certain districts, and analogous to those at present connected by broad physical characters. This arrangement of the groups corresponds also remarkably, and in a most interesting manner, with the differences observable between the generic forms which were then common and those that are now met with. It agrees in the singular fact, that many of the groups of species formerly represented by gigantic types were not confined to one district, but extended over all the known land of the eastern hemisphere. It agrees also with the arrangement of nearly allied species at the present day, many of these being indigenous in distant and unconnected spots now, and having been so formerly. And, lastly, it proves that there is as little evidence to be derived from this branch of geological investigation, as there is from recent zoology and botany, in favour of any view of local or secular development of new typical forms of organic existence; since these modifications are rather produced at once in distant spots, which, so far as we know, were as unconnected formerly as they are at present.

The distribution of the more characteristic land animals in groups is the main fact to be observed in considering this part of the subject; but we should not forget that some important set of causes must also, in all probability, have been in action, tending to produce that singular development of the larger quadrupeds, which has not only peopled the continents and islands of the Old World with gigantic types, but has also affected America, in the southern as well as the northern districts. In that part of the world, as elsewhere, there is a detached and singular group of animals, now greatly limited in distribution, but anciently represented by a large number of individuals as well as species, attaining dimensions not less gigantic in proportion than those of the elephantine monsters or reptiles of India or western Europe, or even of Australia and New Zealand.

CHAPTER XV.

THE CONDITION OF SOUTH AMERICA DURING THE TERTIARY PERIOD.

I HAVE thought it well to bring to a conclusion the argument derivable from the geology of the old continent and its adjacent islands, because, when we consider the case of South America, to which the present chapter will be exclusively devoted, we find ourselves most emphatically in a new world, and surrounded by forms anomalous at first sight, although strictly analogous to the existing fauna of that country, and clearly adapted to its conditions.

The tertiary geology of South America is on the grandest scale, and of the most instructive nature. Flanked by the great mountain chain of the Andes which runs parallel to the western coast, this country is still the seat of disturbances which ought to be studied as exhibiting the true elements of geological causation and illustrating almost every great geological principle. That part of the continent extending from the mountains eastward towards the sea is divided into vast plains drained by the river Amazon and the Rio de la Plata, and separated by a succession of transverse mountain ridges, comparatively unimportant with reference to the subject we have now to consider.

Almost the whole tract of plain country has been affected by strictly tertiary changes, and elevation has taken place at such long intervals and by such slow degrees as hardly to interfere with the condition of things obtaining at the time.* A long succession of animals nearly allied to, but in many cases quite distinct from, its present inhabitants, dwelt on this rising continent; and corresponding groups seem to have existed ever since the first elevation of the country, fragments of them being embedded in the gravel and other deposits at the mouths of the great rivers.

Throughout the whole of Brazil, and in the provinces of La Plata and Buenos Ayres, remains of the extinct quadrupeds formerly tenanting these districts are occasionally met with, and are sometimes not only abundant, but preserved in the most wonderful state of perfection. Some of these skeletons exhibit nearly every bone of the animal; the strong cuirasses of others have scarcely a fragment removed from its true position; and these are found on the banks of the rivers, and in the adjacent mud, while numerous detached bones occur in the caverns in Brazil, and are distributed as widely and buried as safely as the bones of elephants or hyænas in the corresponding places of deposit in England and Europe. We have but to examine the fragments, and re-construct the animals, to learn the zoological condition of the great South American continent during the tertiary period, which indeed may there be regarded as rather passing away, than actually past.

But, first of all, let us consider the nature of the country itself in which these remains are found; and, since there has probably been but little difference in this respect, we shall thus learn at the same time the conditions under which the ancient inhabitants may have lived.

The almost boundless plains, to which in South America the name "Pampas" is given, are localities equally remarkable and interesting to the zoologist, the botanist, and the geologist. They are not actually level, but rather gently undulating; yet, at the same time, the change of level is so gradual and small, that the undulations more resemble the swell of a great ocean in a calm, than any smaller or more visible hills. Over these tracts the traveller may pass for a hundred miles, without seeing any change either in the nature or the products of the soil, and without meeting with a single pebble. They exhibit the appearance of a sea-bottom which has remained for a long period undisturbed; and it is impossible to conceive any thing more monotonous, or in that respect more dreary, than a journey over a desert so boundless. A succession of broad flat terraces, of different elevation, but in all respects similar, characterizes also the whole district of Patagonia from the sea to the mountain chain on the western coast.

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* An account of these will be found in Mr. Darwin's valuable work on the "Geology of South America," published while these sheets were passing through the press.

But it must not be imagined that the vegetation in those tracts partakes of the dreary and monotonous aspect of the country. It is, on the contrary, rich to a degree scarcely imaginable in a country and climate like ours. It exhibits occasionally clumps of well-grown trees, but more commonly the rapid and rank luxuriance of tropical districts. The whole of that part of South America, which is spread out in flat valleys between the branches and trunks of the noblest rivers in the world, is provided throughout with an unfailing supply of moisture, and, consequently, enjoys perpetual fertility; and, as the rivers are frequently changing their course, they thus deposit the rich alluvial soil in various parts, and with it also bury the trunks of trees and the carcases of animals washed away in the occasional floods, or lying dead on the river banks. There is an abundant and never-failing supply for the most voracious of vegetable-feeding animals; and no amount of destruction seems to check, even for a short time, the rapid increase of the grasses and other plants that are indigenous.

At the time when America was first discovered, this vast district was chiefly tenanted by a small number of species of animals of very strange habits and structure, and of which it may, perhaps, be sufficient to say in general language, that they are represented by the sloth, the armadillo, and the ant-eater: we shall presently see what kind of sloths and armadillos were its inhabitants at a yet earlier period. Besides these, there also existed, among the animals indigenous in this continent, a kind of camel called the *llama*, several moderate-sized carnivora, a remarkable group of monkeys, and some interesting forms of rodent or gnawing animals. The group first mentioned (called by naturalists *Edentata*, or toothless, from the absence of cutting teeth) includes the most interesting both of recent and fossil species; but, before describing these, it will be better first of all to consider the structure and habits of those which do not belong to this group, but exhibit analogies with the more common types of animal structure in other parts of the world. Amongst these we find a pachydermatous species, called the *Toxodon*,* showing many curious points of resemblance to the dinothere, but more nearly approaching the rodents (*e. g.* beaver, &c.) in some important respects. There are also the remains of another interesting and very large species, called the *Macrauchenia*, which was a sort of camel, connecting the pachyderms with the ruminants. These have been found to possess considerable interest, and assist in bringing the whole group of fossils more immediately into comparison with those of other parts of the world.

The Toxodon, like the Dinotherium, is chiefly known by portions of the skull, and is almost as remarkable for the position and arrangement of its gnawing teeth, as the giant

* Τοξον (*toxon*,) a bow; *οδους* (*odous*,) a tooth.

of the middle tertiary period in Europe seems to have been for its singular tusks, and their position in the lower jaw. The dimensions of the skull show that the Toxodon must have rivalled the largest quadrupeds in this respect; and its general proportions, its peculiarities of form, and its structure, prove clearly that this extinct genus differed essentially from any other animal hitherto described.

The general form of the skull of the Toxodon seems to present no analogies with that of the elephant, or indeed with any of the larger quadrupeds. The teeth, of which there are seven grinders on each side of the upper jaw, and two incisors, one of them extremely large, and almost like those of a beaver, sufficiently indicate the peculiarities in this respect; and from these the name of the genus has been derived.

One peculiarity in the skull worthy of notice is seen in the slope of the back part of the head, which is characteristic of the Dinothere, and common to the Cetacea and some of the rodents. A very limited capacity is thus indicated, and the indication is strengthened by the exceedingly small space that there is for the brain.

The teeth of the Toxodon are very interesting. All the grinding teeth are long and curved; but unlike the case of the guinea-pig, whose teeth, also curved, are directed outwards, the curve is here such, that each two corresponding teeth of the upper jaw bend over to meet each other in the palate and form an arch capable of overcoming immense resistance to pressure.

The two large incisive teeth, in like manner, bend backwards in their sockets, and extend in an arched form as far as the grinding teeth. The whole of the inside of the upper jaw is thus a vaulted and groined roof of the strongest possible construction; and as the teeth continued to grow and to be pushed forward during the whole life of the animal, there was a constant and continual compensation to meet the effect of the wearing away of the crown of the tooth against opposing teeth of corresponding structure in the lower jaw. The enamel of the teeth is not repeated in distinct folds as in the herbivorous animals of the present day, but the powers of perpetual renovation would amply compensate for this defective quantity of enamel, and enable the animal to grind down vegetable food of the toughest kind, without danger of ultimately wearing away the grinding surface. It is evident, however, from the nature of the attachment of the lower jaw, that the motion of the jaw in the process of mastication was not the same as in the rodents, but admitted of considerable lateral motion and great pressure, assisting in the trituration of the food. There was also a powerful muscular apparatus enabling the jaws to be worked sideways; and it appears from the bones of the face, that those muscles, by which the incisive teeth and the extremities of the jaws were worked, and which form the lips, were also exceedingly large and strong; these fore-teeth being probably used (like the corresponding teeth of the hippopotamus) to divide or tear up by the roots the aquatic plants growing on the banks of the streams which the Toxodon may have frequented. It also appears that the lips of this singular animal were endowed with great sensibility, large nerves having been supplied for such purpose. The expanded muzzle seems even to have been furnished with whiskers.

The extremities of the Toxodon are not at all known, nor can it be distinctly determined whether they were such as to enable the animal to move about on land, or whether, like the dugong and other herbivorous cetaceans, it remained permanently in the water. It is considered unlikely, however, that the latter was the case, although there are not wanting some curious points of structure indicative of its aquatic habits. The affinities exhibited both to the rodent and cetacean orders are very remarkable, this pachydermatous animal, of gigantic proportions, being characterized by teeth which closely resemble those of the gnawing tribes, while the structure of some bones of the skull approaches in many respects to that of the whales.

The knowledge that we possess of the Toxodon is derived entirely from a consideration of some of the bones of the head. We have next to deduce the habits and instincts of another extinct genus, of which nothing is known but a few bones of the trunk and the extremities, without a fragment of a tooth or of the skull to serve as a guide in the investigation. It is the triumph of comparative anatomy that such an investigation is possible; and few things in scientific induction are more beautiful than the nature of the arguments by which, in these cases, the results of the investigation of each bone and fragment of a bone are shown to bear upon and explain one another.

The animal I have now to describe is called *Macrauchenia*,* from the great length and magnitude of its neck, which was very nearly as long as that of the giraffe. Its analogies have been beautifully and admirably worked out by Professor Owen, and he has referred it with great certainty and confidence to the order Pachydermata. It belongs also to that group (containing the rhinoceros and palæotherium) of which the various species are not provided with a proboscis, and have only three toes on the fore-foot. The fore and hind feet of the Macrauchenia were of equal size. The body was nearly as large and massive as that of the rhinoceros, and the length of the legs very much greater. The long neck was not carried gracefully as in the giraffe, but in a stiff and upright position like that of the llama; and the whole appearance of the animal must have been heavy, awkward and ungainly. It is interesting to find that its nearest analogies are with the extinct genus *Palæotherium*, but it also indicates a very beautiful transition from the pachyderms to the ruminants, through the singular group of which the camels and the llama are the existing representatives. A true anoplotheroid animal has recently been added to the list of South American pachyderms.

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* *Μακρος* (*makros*,) long; *αυχην* (*auchen*,) the neck.

We now come to the consideration of those animals more especially characteristic of the latter tertiary period on the continent of South America,—a group of animals perhaps the most remarkable of any that has yet been determined, and one which exhibits a perfect and beautiful adaptation of closely analogous structure in the case of species varying in bulk almost as much as it is possible for those of analogous structure to do. All the rest of the quadrupeds that I shall have to describe belong to the same natural order, which includes, with few exceptions, the great majority of those fossils hitherto obtained from South America. The order, as I have already stated, is called *Edentata*, and is now characterized by the sloth, the armadillo, and the ant-eater. Of the existing species of these animals, the largest is the great ant-eater, which equals in length a Newfoundland dog: of the others, the gigantic armadillo attains about two-thirds of that bulk; and the sloth never exceeds two feet in the length of the body, although its four extremities are disproportionately long. At the time immediately preceding the last change that took place upon the earth, South America was, however, inhabited by numerous animals of this order, some of them rivalling in bulk the largest pachyderms, and others quite as remarkable for their structure, their appearance, and their habits, as for their strange analogies with the sloth and the armadillo.

The sloth is well known and exceedingly common in some of the forests of South America. It has very long fore-legs, so constructed as to support the animal when hanging on the under side of the branch of a tree, and in this position it usually rests. It never willingly descends to the earth, where the peculiar form of its limbs prevents it from advancing without great and painful efforts; but when on a tree it moves rapidly and with ease, passing from one branch to another, and getting from tree to tree by the help of the numerous parasitical plants which form a network uniting the upper branches of the most lofty trees of the forest. The animal is not provided with a tail, and the want of such an appendage is not felt, the bones of the extremities and powerful toes forming an ample support for the creature whether moving or resting suspended from a branch.

It is curious and very interesting to see all the most marked peculiarities of the skeleton, so far as relates to the essential structure of this animal, transferred, on a gigantic scale, to some extinct species, while at the same time the modifications observable in the shortening and strengthening of the legs, and the addition of a powerful tail, are quite enough to convince the physiological naturalist that the actual habits must have differed in spite of much essential and important resemblance.

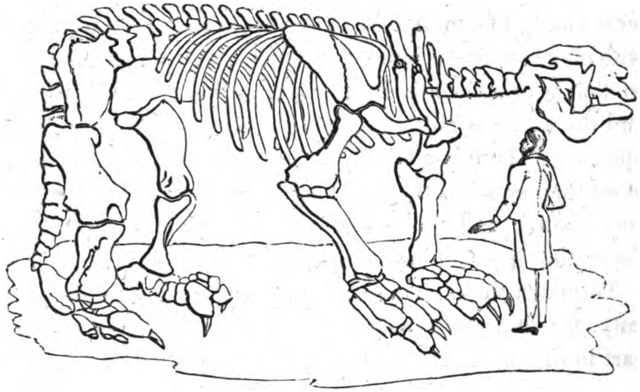
One of these huge monsters has been well named *Megatherium;*[*] and nearly every bone of its enormous body is preserved in a skeleton existing in the Museum at Madrid. Another skeleton, also, of a nearly allied species (*Mylodon,*)[†] smaller indeed, but not less interesting, has been brought to England, and has been the subject of a most elaborate description by Professor Owen, while the skeleton itself, admirably articulated, may be seen in the Museum of the

[*] Μεγα (*mega,*) great; Θηριον (*therion,*) a beast.

[†] Μυλη (*myle,*) a mill; οδους (*odous,*) a tooth.

Royal College of Surgeons in London. The complete structure of an extinct species has in no instance been more satisfactorily made out than in the case before us; and, therefore, the whole nature of the argument by which conclusions are arrived at, from the comparison of the shapes and peculiar projections and proportions of bones, may well be illustrated here by a reference to this remarkable extinct species.

Fig. 145.



MEGATHERIUM.

First of all, let us take a general view of this extraordinary animal, whose singularly massive proportions cannot but strike every one with astonishment.* Its length is nineteen feet, its breadth across the loins nearly six feet, its height not more than nine. The general proportions of the body rather resemble those of the hippopotamus than the elephant; and the trunk itself, much larger than that of any hippopotamus, is terminated by a pelvis, and by hind extremities nearly three times as large as those of the most gigantic elephant. These hind-legs are provided with feet set at right angles to the leg, as in the bear; the heel projects nearly fifteen inches backwards, and the toes, armed with claws, proceed more than twice that distance forwards, so that a proper base is afforded for the massive column, and the whole is able to sustain the weight that once rested upon it. There is also, in addition to the hind legs, a tail more than equal to them in length, and proportionally thick and strong; and this tail must have supported, instead of depending from the broad termination of the pelvic region.

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* See the above figure of the skeleton where the proportions will be recognised on comparing the figure with that of an ordinary-sized man, drawn to the same scale and placed by the side for this purpose.

To match these strange proportions of the hinder extremity, we find the fore-legs longer than the corresponding part in the hind limb, but having a perfect mechanism for free motion in all directions, and connected to the sternum by a very powerful and bony apparatus, also permitting free motion. This extremity was terminated by unusually broad expanded feet, of which the proportions, however, are much reduced in appearance, in consequence of the massiveness of the leg itself, already described. The foot is five-toed; the two outer toes were provided with claw bones of great size and strength, but the whole foot is short in proportion to its breadth.

The skull of this strange monster was exceedingly small and narrow, and was connected to the trunk by a neck of moderate length. The whole body gradually tapers forward from the enormous pelvis and gigantic hind-quarters, which offer a singular contrast to the short neck and slender head. These singular proportions are nowhere met with amongst quadrupeds, except amongst the Edentata, of which the Megatherium is certainly one of the most interesting examples.

Let us now trace the points of analogy that exist between the Megatherium, or rather the megatheroid animals, including under this name the various gigantic species of the same group at present known, and the sloth, the living animal most nearly allied to them.

The first glance at the head of the Megatherium exhibits very striking resemblances to the sloth in several points, some of them peculiar to the whole tribe of edentates, and others indicative of the habits of the animal. The general form is more elongated and straighter, the length however not being due to the prolongation of the jaws (which are cut off shortly,) but to the skull itself; and the structure of the bones of the nose would seem to indicate the existence of a long upper lip, or even a short proboscis. The extreme narrowness of the palate is also worthy of notice, and was, no doubt, in accordance with peculiar habits. The long broad bone, descending by the side of the cheek, is one of those points in which the resemblance to the sloth is carried out very accurately; and this is not less interesting, although we are at present ignorant of its exact meaning. It is characteristic of the whole group of Edentata.

The teeth of the megathere are large in proportion to their thickness, and are gently curved. Their grinding surface is simple and well adapted to the comminution of leaves and twigs. They are all of them molars (grinding teeth,) and there are four on each side of each jaw. They consist of regular four-sided prisms, the outer coating being of bony matter, enclosing a thin inner coating of enamel, and a central mass of ivory; while the opposing teeth are so placed in the jaw that the enamel of each cuts into the softer bone and into the central ivory of the corresponding one, so that a grinding surface is constantly and evenly preserved, and two wedge-shaped cutting edges work into one another, and keep one another sharp.

These teeth were renewed from the root throughout the entire life of the animal, and were gradually pushed forwards as they were needed. They were set very deep in the jaw. It is worthy of notice, that many of these modifications, the narrow palate for instance, the position of the teeth closely set in the jaw, their great length, and the corresponding depth of the jaw,—all exhibit a certain amount of resemblance to the structure of corresponding parts of the elephant, although the fundamental structure of the teeth, and the general form of the skull is at present exclusively restricted to the sloth family.

I shall not dwell long on the description of the vertebral column and the ribs of the Megatherium. The neck is strong, but not remarkably so. It is of moderate length, and differs from that of the three-toed sloth in a point in which this latter quadruped differs from all others, namely, the possession of an additional vertebra of the neck. In this respect, indeed, the two-toed sloth, or unau, (another existing species,) approaches the megatheroid type, but is itself anomalous, exhibiting an increased number of dorsal vertebræ, so that the extinct genus did not agree in this respect with either of the existing sloths inhabiting trees. In the tail, also, the difference is marked not less strongly, for the sloth is unprovided with any such appendage, while it formed a prominent and important organ of support in the Megatherium and other extinct species.

The ribs, both of the Megatherium and the sloth, are broad, and offer a firm support to the body of the animal. Those which are interlocked among each other to form the breastbone offer an example of a very singular structure, found not in the sloth but in the ant-eaters, and apparently intended to assist these animals when burrowing through the earth. The resisting power and the strength thus afforded to the fore extremities was exceedingly great.

But by far the most remarkable part of the megathere is seen in the posterior portion of the skeleton, commencing with the lumbar vertebræ, and including the bones of the pelvis, the tail, and the hinder extremities.

In all these there may be traced a succession of contrivances strikingly indicative of enormous, unwieldy and massive strength; and in all this region there is a total dissimilarity to the sloth, and indeed to all other recent animals of the same natural family. It is almost impossible for any drawing or any description to give an adequate notion of the extent to which strength and massiveness is carried in this animal; but the skeleton figured in a previous page (see p. 339) will perhaps serve to assist the reader.

The first thing to be noticed with reference to this part is the wide expanse of bone stretching out from each side of the vertebral column to a distance of five feet, and scarcely leaving any interval in the hollow of the back. Powerful bones are seen placed at right angles to the spine and vertically over the hind legs, and these form a solid mass well fitted to withstand any amount of pressure, and to enable the hind legs to support without injury almost any effort that could be made by the animal when resting, as if on a tripod, upon its hind legs and tail. This great width also indicates a large size of the abdominal cavity, adapted to the habits of the animal as a vegetable feeder, but at the same time rendering it ponderous and unwieldy.

Articulated to each of the broad plates of bone stretching out thus from the back, we find legs of corresponding magnitude and strength. The thigh-bone is not more than two feet four inches long, but its circumference at the smallest part is equal to its length, while the circumference of the thigh-bone of an elephant is not more than twelve inches. Although, however, the thigh-bone is short, it is set vertically, and not obliquely as in most animals, and its full length is thus taken advantage of, although the rate of progression would thus be in a corresponding degree slow. The size of the leg when clothed with flesh must have been large even in proportion to the circumference of this bone, for it is much flattened and expanded outwards.

The character of strength indicated so clearly both by the proportion, the position, and the peculiar shape of the thigh bone, is fully preserved in the other bones of the leg; for we find the two bones, the tibia and fibula, united together both at the top and bottom, forming an almost perfect column, nearly as large as the femur, and set vertically beneath it. This is a contrivance only characterizing the armadilloes among living animals, and in them it corresponds with an apparatus of the fore extremity enabling the possessor to burrow beneath the surface of the earth. Its object is to offer a powerful resistance to the great pressure exerted when the hind extremities are employed as the purchase, while the fore-legs are being made use of for digging. In the megathere the similar contrivance was, no doubt, useful in very nearly the same way.

The base of the column we have just been considering was no less remarkable for massiveness and extent than was the vast and massive shaft itself. The bone of the instep is a cube of nearly nine inches aside; it rests on a heel bone extending eighteen inches backwards, and the other bones are of similar proportions. The foot was terminated by three toes, one of which appears to have been armed with a tremendous claw. The claw, or rather its sheath, for of the actual claw itself we have no remains, measures upwards of ten inches in length and thirteen inches in circumference at the root; and in this respect, therefore, the analogy with the sloth is still preserved.

The tail of the Megatherium is a part in which the extinct genus differed essentially from the sloth. Its length was very considerable, certainly not less than five feet. The vertebræ of which it is composed are so large, that the circumference of this organ near the root must have been between five and six feet. Large processes are attached to the caudal vertebræ, which would strengthen it greatly; and there are indications on the back of extremely powerful muscles to work it. It assisted, no doubt, in occasionally supporting part of the weight of the body.

Having thus considered the remarkable structure of the hinder extremities and their vast strength, let us turn next to the fore-legs, and learn the relation exhibited by them to the rest of the body.

The fore extremity of the Megatherium consists of a scapula or blade-bone, a humerus or shoulder-bone, two bones of the fore-arm, wrist-bones, bones of the palm of the hand and finger-bones; including therefore every perfection of structure manifested in the mammalian type except an opposing thumb. Some of the fingers are, however, imperfectly developed, and were chiefly useful in locomotion. The length of this extremity does not differ greatly from that of the hind leg.

The shoulder-blade exhibits the general proportions and some of the peculiarities of structure belonging to the class *Edentata*, and more especially possessed by those requiring to make great and powerful use of the fore extremity; and the effect of the contrivances thus alluded to is to give an unusually large and irregular surface for the attachment of those muscles which move the fore-leg. The blade-bone or scapula is connected to the chest by a clavicle or collar-bone, the absence of which in the pachyderms and large ruminants is in accordance with the habits of those animals. The collar-bone gives a steady and fixed position to the socket of the blade-bone, at the same time admitting of a rotatory motion in the extremity. It is the possession of this bone that enables many small animals to carry food to the mouth by the fore extremity, but its chief use seems to be to give strength and stability to the shoulder joint, so that it would be out of place in such animals as the elephant, the deer, or the ox, whose habits are different. In the megatheroid animals, however, the head was small, the proportions of the fore part of the body not excessive, and at the same time there is no reason whatever to suppose that the animal required to move rapidly.

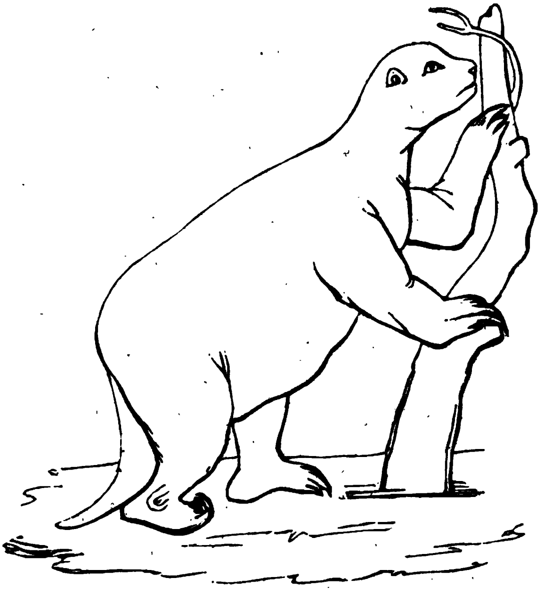
The shoulder-bone of the megathere is remarkable for the enormous size of the lower part. It is small in the middle and upper part, and is connected with the blade-bone by a round head fitting into a socket and admitting of free motion. At the lower end, however, where it is attached to the arm-bones, it attains an immense breadth, and served for the attachment of muscles of extreme and unusual magnitude, working the fore-foot. The use of this expansion is obvious, if we compare the shoulder-bone of a ruminating animal, where the crests are scarcely observable, with the corresponding bone in the elephant and rhinoceros. In the ant-eater this contrivance is carried yet further, and by its means the animal is greatly aided in digging up the large solid nests of the white ant. The bones articulated to the large termination of the shoulder-bone correspond well in magnitude and strength. The one is broad, powerful at its upper end, and short, and the other revolves freely upon it, giving that motion of the fore extremity by which man is able to move his hand on either side by a simple motion of the wrist.

The entire fore-foot must have been a yard long and twelve inches wide. It was provided with five toes, three of which were conspicuous for their large proportionate size, and were armed with long and powerful claws. The other toes did not appear outside the foot, being only rudimentary.

The account which I have given of the skeleton of the Megatherium requires but little modification when we turn to the other smaller animals of the same kind living at the same time, and found in the same locality.

The *Mylodon*, the one best known, was smaller than the megathere, its trunk being shorter than that of the hoppopotamus, although the pelvis and the bones of the extremities were greater than the corresponding parts in the largest elephant. The chief differences that exist between this genus and the more gigantic one already described, are seen in the nearer approximation to the sloth exhibited in the form of the skull, and several modifications of little importance that characterize the teeth. The fore extremities,

Fig. 146



also, were terminated by only two instead of three-clawed toes, but in all important points the animal was the same.

The figure presents an outline of the animal as it may have appeared when engaged in obtaining food from the trees of the forests it inhabited. The attitude is the same as that in which the perfect skeleton in the Royal College of Surgeons is set up.

The *Megalonyx*[*] is another genus, chiefly known by bones of the extremities. It appears to have had the thumb more developed, and greater freedom of motion of the fore extremity. In other respects, and in its proportions, it probably resembled the Mylodon.

The *Scelidotherium*[†] differs rather more from the megatheroid type than either the Mylodon or Megalonyx, and even exceeds them in some of those monstrous proportions for which they are so remarkable. It is also interesting as exhibiting a transition to the ant-eater and armadillo, which it resembles more than the sloth in the form and structure of the skull. In all important points, however, as well with regard to the head as the vertebral column, and also in the dentition, the scelidothere and the Megatherium are so closely analogous that they hardly admit of a separate description. In the fore extremities the same singular contrivances present themselves; and in the hinder extremities and the tail, the strength is perhaps greater in proportion than in any known animal, living or extinct.

Of these bones the femur, or thigh-bone, is the most remarkable, and it differs in some points from the corresponding part of the megathere, its breadth being greater in proportion to its length than is the case even in that singularly proportioned animal. It appears, that, although the total length of the scelidothere could not have been greater than that of a Newfoundland dog, the fore extremities not being larger, and the height not nearly so great, the hind extremities were more gigantic than those of the largest rhinoceros or hippopotamus, and the animal was provided with a tail so thick and strong, that there is nothing in existing nature with which to compare it.

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[*] Μεγαλη (*megale*,) great; ονυξ (*onyx*,) a claw.

[†] Σκελις, gen. σκελιδος (*scelidos*,) the thigh; θηριον (*therion*,) beast.

We have now only to consider what can have been the habits of animals so strangely organized, resembling the sloth in the structure of the teeth and other characters which mark the food to have been the leaves and tender twigs of trees, but rather approximating to the armadilloes and ant-eaters in certain peculiar contrivances for strength which in these living edentates are connected with habits of digging and burrowing beneath the surface of the earth. All the extinct species we have yet discovered of the group attained dimensions which seem to have unfitted them entirely for any such habit, neither allowing them to climb trees like the sloth, or to burrow like the mole, the ant-eater, or the armadillo.

We know that the general proportions of the megatheroid animals resemble those of the elephant; but, although their body was relatively quite as large, their legs were shorter and much thicker, and their fore extremities were endowed with greater facilities of motion.

The head, moreover, is very diminutive, and the neck, although longer, was not so much so as to enable the animal to reach to any height above its body. It is also quite certain that these animals could not have had a long proboscis, and some had no proboscis at all; so that the question presents itself, how they could have obtained the leaves of trees, which the structure of their teeth shows to have been the only food adapted for them.

Now we have seen, in the course of our investigation concerning the peculiarities of structure of these animals, that they exhibit in all cases very remarkable modifications of the extremities, the hinder part of the body being enormously large, powerful, and massive, and bearing every mark of the greatest possible adaptation for resisting pressure, forming as it were a *point d'appui*, from which the rest of the body could act with safety and certainty. It is also the case that the fore extremities were exceedingly powerful, but in a different way, admitting of free motion, and provided with large and prominent claws, so that they were well adapted for grasping the trunk or the larger branches of a tree, while the forces concentrated upon them from the broad posterior basis are such as could well assist in the act of wrenching off a branch, or even, if need were, uprooting a tree.

There is, indeed, no other reasonable conclusion to be drawn from the consideration of the framework of these gigantic quadrupeds. Their massive proportions cannot but arrest the attention of even the most indifferent beholder, and such proportions seem to imply powers and actions as peculiar to the living animal, as are these modifications to the framework of the body handed down to us.

The enormous pelvis of the Megatherium proclaims itself the centre, whence muscular masses of unwonted force diverged to act upon the trunk, the tail, and the hind legs; but, in order that it should possess stability and resistance equivalent to the due effect of the forces acting from it, it required to be bound down and supported by members of corresponding strength.

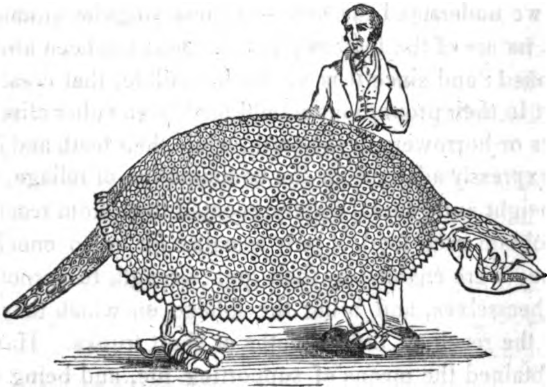
We find, accordingly, a thigh-bone, which, though longer than the shoulder-bone, is half as broad as it is long, and is provided with bony crests, giving unequivocal evidence of the magnitude and power of the muscles once attached to and working from them.

This thigh-bone, placed vertically, rested on leg bones of corresponding magnitude, and on a foot which in all its proportions must have served as a fit basis for the leg. The foot was of great length (equalling, if not surpassing, that of the femur;) the prolongation of the heel served as a fulcrum, and the powerful claw of the middle toe held fast to the ground, at the moment when the forces of the fore-limbs were exerted. There was also a strong and powerful tail, its proportions being exactly such as to complete with the two hind legs a tripod strong enough to afford a firm foundation for the massive pelvis, and sufficient resistance to the forces acting from that great bony centre. The proportions of these parts, colossal as they are, lose their anomalous character when we view them as the fixed point towards which the fore part of the body was to be drawn when the animal was in the act of uprending a tree to serve as its subsistence; and the value of all these contrivances is seen when we understand the habits of these singular animals.

The nature of the food required by them has been already mentioned; and since it is utterly incredible, that creatures so vast in their proportions should have been either climbers of trees or burrowers in the earth, while their teeth and jaws were expressly adapted for the comminution of foliage, and their height and general form prevented them from reaching up to obtain such food, it only remains for us to conclude that they were enabled by their great strength to uproot the trees themselves, and bring the foliage on which they fed within the reach of their mouths or short trunks. Having thus obtained the means of supporting life, and being provided with a tongue of remarkably large size and strength, not less adapted than that of the giraffe (and apparently even larger and stronger in proportion,) the creature was thus enabled to strip off the leaves and smaller branches, which the absence of teeth in the front of the jaw left to be performed by such agency. Every contrivance was introduced to fit these animals for the performance of certain offices in the ancient forests of South America, which are now executed by a multitude of smaller animals, not very dissimilar in many points of structure.

The megatheroid animals, however, are not the only gigantic species of the edentate order living at this period. Associated with them was an armadillo, almost as colossal in its proportions and quite as anomalous in its structure. This animal has been called the *Glyptodon*,* and it exhibits in the complicated structure of its teeth an approach rather to the pachydermatous type shown in the Toxodon than to the megathere or the existing armadilloes, while in other respects it seems to have connected the edentates with the heavy-côated rhinoceros.

Fig. 147



GLYPTODON.

The Glyptodon, like the armadillo, was covered and defended by a shell not unlike a coat of mail, made up of round or many-sided pieces, fitting one another accurately,

* Τλυπτος (*glyptos*,) sculptured ; *οδους* (*odous*,) tooth.

continuous over the whole of the upper part of the body, and covering the upper surface of the thick and powerful tail. The armour is massive and very heavy, and when detached from the body resembles a barrel.

The bones of the leg and foot, perfectly adapted to bear the steady pressure of an enormous weight, are extremely interesting. They present the frame-work of a foot of such structure and form as is without a parallel in the animal kingdom, so admirably is it contrived to form the base of a column destined to support a vast superincumbent weight, and at the same time to allow of that degree of motion of the fore extremities which is required for the scratching and digging operations of animals like armadilloes. The Glyptodon can only be matched by the great land tortoise, whose remains are found fossil in the Sewalike Hills; and we may almost consider it to have represented this monster, performing a nearly similar part, and clearing away the decaying animal and vegetable matter, that might otherwise have accumulated and become mischievous. Several species of gigantic size have been determined from the examination of fossils brought to England, and now preserved either in the British Museum or the Royal College of Surgeons.

The inhabitants of the central plains of South America during this period appear to have wandered northwards as far as the southern districts of North America, while the Mastodon of the countries ranged southwards into Brazil. Whether the means of passage consisted of continuous or broken land on the eastern side of the Gulf of Mexico, or whether the high land of Mexico itself even then connected the two continents, we are not at present able to tell, but the very broad distinctions that there are between the extinct faunas of this comparatively modern period, as exhibited by the fossils of North and South America generally, as well as the great difference observable in the recent faunas, would rather lead us to conjecture that the species common to both may have been conveyed accidentally, and that these two great tracts of land in the western hemisphere were anciently detached from one another.

However the case may have been in that respect, it is interesting to consider the condition of this part of our earth at the period immediately antecedent to the introduction of man. Instead of a country remarkable for the absence of all large quadrupeds, it was exactly the reverse, but these ancient giants are now represented by smaller although similar species. The Pampas then, perhaps, presented a condition of vegetation little different from that still characteristic of them; numerous clumps of forest trees were dotted about at intervals, and the intervening country was covered for the most part by rich and luxuriant vegetation. Other trees probably fringed the margin of those gigantic rivers which still pour out their torrents of water and drain a mighty continent. In the half swampy tracts, or in the pools formed by the shifting beds of these rivers, the Toxodon then dwelt; and over the broad plains the Macrauchenia slowly paced. At one spot, numerous bare trunks of trees, stripped of their verdure, rotten and half decayed, or alive again with the busy tread of millions of ants and other insects, mark the vicinity of the great leaf-eating tribe. The Glyptodon, with his heavy tread, slowly advances under the weight of a thick and cumbrous coat of mail, and finally clears away the half-destroyed vegetation. The smaller species of the megatheriod family—each one, indeed, a giant in his way—feed on the younger and smaller plants, tearing them up by the roots or reaching from the ground to devour their foliage.

But presently the Megatherium himself appears, toiling slowly on from some great tree recently laid low and quite stripped of its green covering. The earth groans under the enormous mass; each step bears down and crushes the thickly growing reeds and other plants; but the monster continues to advance towards a noble tree, the monarch of this primæval forest. "For awhile he pauses before it, as if doubting whether, having resisted the storms of so many seasons, it will yield even to his vast strength. But soon his resolution is taken. Having set himself to the task, he first loosens the soil around the tree to a great depth by the powerful claws on his fore-feet, and in this preliminary work he occupies himself for awhile: and now observe him carefully. Marching close to the tree, watch him as he plants his monstrous hind feet carefully and earnestly, the long projecting claw taking firm and deep hold of the ground. His tail is so placed as to rest on the ground and support the body. The hind legs are set, and the animal, lifting itself up like a huge kangaroo, grasps the tree with its fore-legs at as great a height as possible, and firmly grapples it with the muscles of the trunk, while the pelvis and hind limbs, animated by the nervous influence of the unusually large spinal cord, combine all their forces in the effort about to be made. And now conceive the massive frame of the Megatherium convulsed with the mighty wrestling, every vibrating fibre reacting upon its bony attachment with the force of a hundred giants: extraordinary must be the strength and proportions of the tree, if, when rocked to and fro, to right and left, in such an embrace, it can long withstand the efforts of its assailant." (Owen, on the Mylodon.) The tree at length gives way; the animal, although shaken and weary with the mighty effort, at once begins to strip off every green twig.

The effort, however, even when successful, was not always without danger.* The tree in falling would sometimes by its weight crush its powerful assailant, and the bulky animal, unable to guide it in its fall, might often be injured by the trunk or the larger branches. To guard against some of this risk, the skull, the most exposed part, is found to exhibit more than usual defence against injury. It is more cellular than is usual with other animals, and the inner and stronger plate is covered with an outer table and intermediate walls, to resist a sudden and violent shock.

Thus does it appear, that at a very recent geological period, and perhaps not long before the actual introduction of man upon the earth, a multitude of strange and monstrous animals tenanted various districts; that each group was then, as it is now, distinct from the rest, although so organized as to perform the same part in nature; and yet more, that each group possessed certain peculiar characters, exhibiting a relation with the animals still inhabiting the same districts, although the actual species are greatly changed, being modified in form, in proportions, and in habits. It would not be easy to imagine sets of phenomena more instructive, or more suggestive of new ideas and new views of creation; nor could any plan that we can conceive have indicated so clearly the uniformity of action, and the multitude of different means used to bring about the same great end. We shall consider in the next chapter the general conclusions that are suggested from this study of ancient nature.

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* In the specimen of *Mylodon*, in the College of Surgeons, the skull has undergone two fractures during the life of the animal, one of which is entirely healed and the other partially. The former exhibits the outer tables broken by a fracture four inches long, near the orbit. The other is more extensive, and behind, being five inches long, and three broad, and over the brain. The inner plate has in both these cases defended the brain from any serious injury, and the animal seems to have been recovering from the latter accident at the time of its death. (See Professor Owen's Memoir "On the Mylodon," &c., p. 22, *et passim*. Many of the remarks in the present chapter have been borrowed from this admirable monograph.)

CHAPTER XVI.

GENERAL CONSIDERATIONS CONCERNING THE RESULTS OF GEOLOGICAL INVESTIGATION.

No one can properly consider the nature of geological researches, and the extent to which they indicate the ancient history of the globe and its inhabitants, without being struck by the simplicity and grandeur of the great plan of creation, and the adaptation of certain typical forms of organic life to a vast variety of different conditions, examples of which seem to have been introduced in regular order from the beginning of the world till now. In the preceding pages I have endeavoured to give, in the way of narrative, an idea of some detached but characteristic events of this history, and a number of sketches of the different epochs, or times when the conditions were most peculiar and most instructive.

In carrying out this object, however, I have frequently been forced to dwell rather upon the differences than the analogies that may be traced in the structure and adaptation of successive groups, and have directed attention so often, and in so marked a manner, to these differences, that some of my readers perhaps might over-estimate their importance, did I not now, in summing up the nature and value of the evidence already given in detail, explain how far such an impression may be considered correct. In the present concluding chapter, therefore, I propose to take a general view of the whole subject, tracing as far as I am able the gradual development of life upon the globe.

Now a very superficial glance at general natural history will show, that however great the difference may be between the groups characteristic of any two geological periods at the same spot—a difference, therefore, corresponding to a lapse of time—the distinction is equally marked at the present day in living groups with respect to space. Whatever, also, may have been the law anciently in force with reference to the succession of organic beings on the earth, and the introduction of new ones, that law, so far as we can tell, is permanent and uniform.

It appears, therefore, that a vast and comprehensive plan still perhaps only partially unfolded, marks at once the infinite wisdom, the infinite power, and the infinite goodness of the Creator; and we may also conclude, that this method of action, or, if we will so call it, this law, may involve in its vast compass, not merely our own planet, but some or all of those orbs which circle round our sun, and perhaps, also, those unnumbered systems, which, like our own, are in motion through space. It is possible that all these bodies may in their progress exhibit an analogous method of development, consisting of the elaboration of series of groups, alike and yet different, each perfectly adapted to its purpose in its own way, and each having direct reference to all the rest.*

I am quite prepared to admit that the advance of accurate scientific knowledge may be so considerable as to enable man at some future day to comprehend not only a few of the details, but even the general nature of this great plan of development. But he is certainly not yet in a condition to perceive the bearing of all those facts which are presented for his study, or to obtain a comprehensive view of the broad generalizations they involve; and in the attempt to include them within the compass of his imagination, and express their true relation in language, he has hitherto always failed. Convinced as I am of this, I offer with great diffidence those general conclusions on the subject in question which I have to suggest; and if I should be myself accused of speaking less cautiously or more dogmatically than may seem fit, I can only repeat this expression of my earnest endeavour to avoid such a form of speech. On the other hand, while I would not wish to blame others for giving decided expression to their own views, I would still caution my readers against the premature and unwise attempts that have been made by some authors to explain and bring within the compass of an assumed law of development the obscure and isolated phenomena hitherto observed and apparently bearing on this subject,* whatever those views may be.

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* It should, however, be distinctly understood, that there is not the slightest reason to suppose any actual repetition of the same plan. The evidence we have on the subject would rather lead us to conclude the contrary; but there may still be that amount of analogy which involves unity of plan.

If, from the study of fossils, we seem to attain any definite notions concerning the general plan of creation, these, it must be remembered, are only valuable so far as they can bear comparison with observations concerning existing nature, and the present condition and relations of organic and inorganic matter. The moment that we pass beyond this limit, that moment we launch without compass into a vast and boundless ocean of conjecture, guided only and warned by the appearance of innumerable wrecks, the results of similar attempts, which serve to point out the danger, but hardly teach us how to avoid it.

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* The law of development to which I here allude, supposes the successive elaboration of organic beings, each new form exhibiting higher or more complex organization.

In the actual condition of the earth's surface we find abundant proof of change of almost every kind. Nothing is permanent, nothing continues in a condition absolutely the same for more than the shortest possible time: there is movement, disturbance, modification going on, above the surface, on the surface, and beneath the surface—everything is in motion, not a particle of matter in the whole universe stands still, and every thing is manifestly tending to a somewhat different state, though there appears every probability that the new state will be strictly analogous to the old one.

In the case of inorganic nature, this perpetual turmoil is now universally recognised. Not only does the earth move as a mass, but every particle of matter seems to be constantly changing its position in relation to the adjacent particles. The air is constantly receiving, conveying, and distributing particles of earth and water. The water is in constant movement from the action of the winds and tides, from the influx of rivers, and from unequal evaporation from its surface. But the surface itself is yet more decidedly exposed to change; for not only is part carried from one place and deposited in another by every dash of the never-tiring wave, and every drop that falls in the form of rain, but there is a constant tendency in the parts below the surface to re-arrange themselves in some other order—to obtain an equilibrium which is no sooner obtained than it is lost. All nature is thus animated; the sea is never so quiet, the air is never so calm, the earth is never so fixed, but that these silent and invisible, but appreciable changes still go on.

And these changes, we are taught by the most careful observations and measurements, have much more than a mere superficial and momentary character. Large tracts of land are being even now upheaved, and others are depressed. But a few years—and what is now a flat coast-line may present a steep cliff; and large tracts of land now above the water may then be submerged. Streams and rivers bring down mud, and by this mud choke up their own channels; but they soon make other channels, which, after a time, are closed in a similar way.

But if this is the case with regard to inorganic matter, how much more strikingly is it true when we consider the nature of organic life. A constant replacement of every part, both solid and fluid, which is endowed with the mystic power of life, seems to be the first requisite for its existence, and the essential attribute of its presence. Every particle of the solid frame-work which supports our bodies will, in a few weeks, or at the most a few months, entirely disappear, only, however, to give place to other particles arranged in like manner. Individuals are in the same way represented by their offspring; and this representation is carried out in nature, not only with families of individuals, but also with those groups into which we collect similar beings, organized with the same characteristic peculiarities. Every thing in nature speaks of substitution and representation—a permanence of idea, but a ceaseless change in the individual.

Analogy, therefore, would teach us to expect that there has always been and must always be this amount of change. But does analogy go no farther? In the case of some animals, the young is first brought into the world perfect in its kind, and filling a definite place among created beings, but not adapted to the habits, and apparently not possessing the structure and peculiarities of the parent animal. But the young becomes at length more perfectly developed, acquiring a greater variety of wants and of powers, and gradually seeming to exhibit a more complex, or, as we are in the habit of considering it, a higher organization, but only seeming to do so. Here, therefore, we have analogy of a remarkable kind, not without its meaning, and worthy of being referred to as a key in explaining difficulties. We know not why or how it is that the egg of a butterfly, when it has existed for a certain time, and has been exposed to a certain temperature, becomes a worm, greedily devouring green food, rapidly increasing in size, and performing the important part it is known to do in the economy of nature. Still less, if possible, can we judge of the cause why this worm, after a time, building for itself a warm coat of silky fibre, burying itself, as it were, in a shroud of its own manufacture,—ceasing to feed, and scarcely remaining alive,—at last bursts forth in the form of a parent animal, and lives for a short time on the tender juices of flowers. Surely this is not less remarkable, although the phenomenon is more familiar, than the succession of species which we observe to have taken place during the lapse of time, or the representation of species well known to exist over wide areas in space.

The analogy is not greatly strained, if we suppose that the original plan of development of all organic nature, whatever it may have been, included succession and representation of species, just as the development of the moth includes metamorphosis: nor is it unphilosophical to suggest such an illustration as an explanation, not only safe to a certain extent, but even satisfactory with regard to many of the difficulties presented by this subject.

But there is no appearance in nature, and nothing in geology, that can enable us to explain by progressive development the gradual derivation of new types, or well-marked groups, of higher organization from those which preceded them. In the oldest formations we find corals, star-fishes, crustacean animals, and shell-fish (mollusca,) together with a very few fragments of small fishes. We know not accurately how far these may have been the products of a deep or a shallow sea—of an ocean far distant from land, or a sea whose coast-line was immediately adjacent. We know not either whether this sea was warmer or colder than the sea that washes our coast now. But this we do know, that of all these animals, each is perfect in its way, each is fully developed after its kind. The trilobite had perfect vision by its hundred eyes—the cuttle-fish powerful and perfect weapons of destruction, ample means of escape from danger, and an admirably contrived chambered habitation—the fish had its strong defence of enamelled scales. Nor were the corals, the cuttle-fish, the crustaceans, or the fishes of after times at all more highly organized in these respects.*

And such is the case throughout. The reptiles which first appeared belonged to groups more complicated in their organization than many of those which succeeded them. In all ancient forms of animals, also, as in their existing analogues, there is adaptation as well as development. These two great principles proceeded, it would seem, hand in hand, side by side, carrying out the great plan sketched from the beginning. Wherever there was room for an animal or vegetable of a certain kind, there that animal or vegetable was introduced, bearing its mark as belonging to a special group, and exhibiting the closest resemblance to some other organic form, filling elsewhere, or at another time, the same office. There is, however, very rarely any absolute identity of specific form in the individuals or groups characteristic of times or places removed by a great interval.

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* Still, it must not be forgotten that there is in the structure of some of these animals, and especially the fishes, a singular limitation to what is now the character of the corresponding species at an early period of the development of the individual.

There is hardly any fact in natural history more distinctly the result of observation, or more valuable as suggesting a great law of nature, than the strictly co-ordinate relation which space and time bear to development in organic existence. In the comparative repose of the open sea, on a calm day, in deep water, we find floating on and near the surface myriads of animals and vegetables of the very simplest organization, (*Foraminifera*, *Medusæ*, *Confervæ*, and *Fuci*,) and these differ but little, whether we examine the waters of the high northern latitudes, the seas of the tropics, or those of the Antartic zone; and in rocks that appear to have been formed in deep water we find very generally the remains of similar animals, as far as they are capable of being preserved; their range in a fossil state being as considerable in a verticle direction as it is horizontally with vertical regard to the recent species.*

These minute animals, standing as they do on the extreme verge of animated existence, perform also, in all probability, (a suggestion for which we are indebted to Professor Owen,) the important office of bringing back into circulation a vast quantity of organized matter, just when on the point of being dissipated into its chemical elements. The animalcules soon become the food of other creatures of somewhat higher organization; and they supply in this way, and very rapidly, sufficient nourishment for the numerous and voracious tribes of Mollusca, crestaceans, and fishes that inhabit the water.

The course of nature in this respect seems to have been at all times the same. Certain Mollusca of low organization, the so-called *Brachiopoda*, not many steps removed from the animals of the former group (*Zoophyta*,) appear to have been, next to them, among the most widely extended groups, constantly represented in closely allied, if not identical specific forms. In other words, they are the most cosmopolitan of existing Mollusca; they are gregarious and often live in great depths of water, but lastly they have considerable vertical range, and are greatly similar to one another in their development in time. Some, no doubt, of the highest Mollusca, nearly related to the common squid or cuttle-fish, are also very widely spread, but this arises from the free-swimming habits of the animal, and is therefore to be considered as having a different cause from that which obtains in the former case, where the animal, at least in the full-grown state, is permanently attached to some submarine body.

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* In the case of infusorial animalcules, the same species (the inhabitants of fresh water) have been found living in the southern extremity of South America and in Europe; while species at one time supposed to be peculiar to America, have been found associated with African land species in the dust that has fallen upon vessels far out at sea in the Atlantic.

No animals, again, at the present day, are more widely distributed than those which secrete and deposit in various ways solid calcareous matter; and of all these it would be difficult to find any that have greater influence than some of the smaller zoophytes. It is just these animals also whose remains are distributed through rocks of various ages, and which, therefore, seem to determine least effectually, in time as well as space, any important point with regard to the true geological position of a containing rock.

If, leaving the Invertebrata, we examine the various groups of vertebrate animals, a nearly similar result is obtained. Certain groups of fishes now characterize certain limited districts, and this without our being able to discover any reason for it. Of these groups some exhibit much higher organization than others, and present marked differences of habit and structure, while some, on the other hand, are more widely distributed and more nearly cosmopolitan. On our own coast, again, we should find buried at moderate depths, and at no great distance from the coast-line, a multitude of animals, exhibiting probably but few decided indications of the vicinity of land except within the range of comparatively shoal water. On the coast of America, on the contrary, there would be extensive deposits in the open sea, at a distance of several hundred miles from the coast, containing occasionally plants and animals floated down by the vast rivers of that continent, and conveyed along on the surface by the river stream and the marine currents. On the coast of Asia we should probably have striking indications of the existence of animals of high organization; while on the coast of Australia there would be scarcely any mark of higher conditions than those which are known in the oolitic rocks. Lastly, in those distant parts where the ocean is broad and deep, and the islands small and scattered, there might only be seen the remains of imperfectly organized Foraminifera, mixed perhaps with a few Radiata, such as the deep-sea urchins, and fragments of some free-swimming animals.

Now it is important to consider these great differences, because they lead us to the only true means of judging with regard to geological phenomena. Any one visiting in succession Australia, South America, Europe, South Africa, and Asia, and looking at the animal kingdom without taking man into account, might come to the conclusion, that, in point of development and complexity of organization, there was on the whole a distinct advance in the scale of beings; or that, in other words, the indigenous mammalian animals or quadrupeds existed in a condition less removed from that of birds and reptiles in Australia than in South America, in South America than in Europe, in Europe than in South Africa, and in South Africa than in Asia, since, in the first-named district, he would find the marsupial or pouched animals exclusively present, in the next the edentates most characteristic,* in the third the ruminants, in the fourth the pachyderms and carnivorous animals, and in the last the pachyderms, Carnivora, and monkeys. Would he for this reason, however, be justified in concluding that in either case the kind of progress exhibited in Nature's works would gradually bring out edentates from marsupials, ruminants from edentates, carnivora from ruminants, or monkeys from carnivora? We may safely assert that such a conclusion would be false; nor is there, in any case, the shadow of probability that progress or development of this nature has ever existed. And when, in examining rocks of different age, we discover marsupials in the oolite, what is the actual evidence with regard to the other groups of quadrupeds? It is simply this, that in the next newer beds in which the remains of quadrupeds appear, there are marsupials, ruminants, pachyderms, carnivores, and monkeys, indiscriminately mixed together; and with regard to the three latter groups, it is not easy to determine which of them was the truly characteristic one; for, though the remains of the pachyderms seem to be more abundant than any others, this may well be a result of their peculiar habits and the swampy condition of the land near where the beds were deposited, and we know that such animals are at present, and may well suppose that they always were, associated with numerous and powerful species of Carnivora.

Besides, however, these facts with regard to the present distribution of quadrupeds, we find that the distribution of the groups in times not long past exhibited a strictly analogous class of results. In South America, for instance, the horse and several other pachyderms, several hollow-horned ruminants, and some carnivores of larger proportions than now exist, anciently inhabited the country and were contemporaries of the gigantic edentates. There is some evidence also to prove that North and South America were formerly united much more directly than they are now, the more highly organized group seeming to have been destroyed in the southern part of the continent, but having been retained in the northern. So also in England and western Europe we find fossil monkeys, and indications of vast multitudes of large Carnivora and pachyderms, although these animals have there been for a long time nearly or altogether extinct.

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* In South America there is now not one indigenous species of the hollow-horned ruminants (ox, sheep, goats, &c.,) and the pachyderms and Carnivora are few in number of species, and of small size. This was not the case, however, during the Tertiary period.

The result that we are forced to arrive at from such considerations as these is, that climate and atmospheric conditions, the consequence probably of differences in the quantity of land above water in certain districts, in the relative position, the extension, and the level of the land, combined, it may be, with other causes concerning which it would be idle to speculate, had far more to do with the extent and the true nature of the organic forms, than any incomplete development of the mammalian class.

The notion of a true progressive development, the geologist therefore, as well as the zoologist and botanist, must except against. There are no good grounds for believing in its existence in any case at present; and the history of the past is decidedly opposed to the idea of such a plan having ever been in operation.

Nature, in fact, will not allow herself to be tortured into our systems, nor will she adapt herself to the procrustean bed of any system-maker amongst us. The infinite ramifications of life, the thrusting in, as it were, in every spot where life is possible, of those animals and vegetables best fitted to exist under such circumstances; these of themselves are sufficiently important facts, and speak clearly enough to check presumptive and hasty generalizations, if indeed it were possible to check this natural tendency to advance too hastily to conclusions. At all degrees of temperature, from the surface of snow to the boiling water of hot springs; in all soils, from the rich land of the tropics to the barren desert; on the whitened surface of pure salt and on the naked rock on the mountain summit; in all degrees of light, from the full glare of sunshine to the darkest recesses of the rocky cavern; in air and in water; upon the earth, and even beneath the earth; at all times, from the first introduction of living beings until now—we find pressing in on every side abundant evidence of this marvellous fact, this perpetual miracle. We are surrounded by the results of life, and most of the productions of art are derived from materials first elaborated by organic bodies either animal or vegetable, and in that state afterwards made available.

Notwithstanding this vast and exuberant presence of organic existence, it is yet true that we cannot even imagine the nature of the broad line of demarcation, which seems, as it were, to form an impassable gulf between that which we call living, and that which is only dead matter. Life is no less a mystery to us now, than it was when man first speculated on its nature. We know not what it is, why it is, or how it is; we know only that it exists, and is every where present. The development of one form of life from another may therefore well remain undetermined, since we cannot even guess at the nature of that first change which produces organization, and which thus modifies and acts upon inorganic matter.

From the investigations of naturalists concerning various groups of animals of high organization, as they are now distributed in different parts of the world, there is therefore, I repeat, no support for any theory of the progressive development of species; while the comparison of the species themselves, and of the groups which they form, with those found fossil, or which have been their representatives in former times in the same districts, is equally opposed to any such view. It should be borne in mind also, that, in taking the case of quadrupeds, we are acting with perfect fairness, as they are the animals of which we know most, while on the other hand the evidence they offer is by no means the most favourable illustration of the view advocated, since the reptiles offer matter for consideration which is yet more unanswerably opposed to the theory of successive development. Without, however, dwelling longer on this subject, I would now, in conclusion, endeavour to bring together, and place before the reader in a simple and intelligible form, some of the general results of geological investigation.

It appears, then, from the observations that have been made,—

First,—That the earth has always been subjected to two kinds of forces acting on a grand scale, and over large tracts. Of these forces, the one class (called igneous) is connected immediately with heat, and has been generally, if not always, deep-seated, producing its effects partly by modifying and metamorphosing other rocks, partly by elevating large tracts, and partly by protruding heated, and sometimes molten matter through the surface. The other (aqueous) is essentially and necessarily superficial—in acts chiefly where land and water are in near and extended contact, it tends to diminish the inequalities of the earth's surface, and it has its efficiency greatly affected by the corresponding action of the former class of forces. It also appears that we have no distinct proof, although there seems high probability, of that condition of things found in the lowest aqueous rocks having been the first, for it is quite possible that conditions of formation and subsequent modifications may have produced all those peculiar characters on which we found our judgment concerning points of this kind.

Secondly,—That during the deposit of the oldest known fossiliferous rocks, which was certainly an early, if not the very earliest, period of the earth's history, there was great uniformity of general character amongst the various animals whose remains occur in rocks of the same age, over almost the whole world, throughout a vast thickness of deposit. But there are no distinct indications of any other conditions having then existed than might even now obtain, with certain very trifling modifications, in some districts, either of the northern or southern hemispheres.

We have not yet, in these old rocks, obtained any proof of the vicinity of land; and even the absence of fishes, or their great rarity, although an important negative fact, must not be assumed to prove absolutely that no fishes existed at that time. Animals of this kind may have abounded in other parts of the sea, although the districts where we now find the older fossiliferous deposits were possibly unfit, through local conditions, for supplying their wants.

Thirdly,—That in the next succeeding period, when fishes were very abundant and of extraordinary form, and where there is also distinct proof, in the presence of coal, of the existence of land near many of those parts of the earth which are now occupied by the deposits of this age, we are not obliged to suppose that the land or coast-line was very extensive, that it was every where unpeopled by quadrupeds and reptiles, or that, even if such was the case, it possessed a different atmosphere, or a very greatly increased temperature. The parts of the world now most abounding in vegetable life are not those in which animal remains would most frequently be deposited; and those containing the most nearly allied vegetable forms are neither tropical in climate, nor are they districts in which reptiles or quadrupeds now abound at all. A very broad line of distinction should be drawn between positive and negative evidence in cases like these, where we are so entirely dependent on analogies. Making, however, all allowances, it cannot but appear as a very remarkable and interesting conclusion, that there should have been in many different countries, extending from high northern latitudes to Van Diemen's Land, at the same geological epoch, and under nearly similar circumstances, this extensive deposit of vegetable matter; nor is it easy to avoid the conclusion, that there must have existed some conditions distinct from those which have since obtained, and that these acted with great comparative uniformity, since they produced such similar results. There are few problems in geology, the solution of which would be more interesting and instructive than that of the origin of coal; and this perhaps is a matter not altogether hopeless, since the careful and minute investigation of the associated beds of shale and stone, so well laid open in the numerous excavations made to obtain the coal from its bed, affords material of unusual value and extent, available for this purpose.

Fourthly,—It appears that the period which succeeded the palæozoic age was one during which various singular and gigantic reptilian animals were introduced, and that these animals then lived in great numbers, and occupied a most important place both among the vegetable and animal feeders; but judging from the fossils of this period, we are still without distinct evidence of there having been any such difference in climate as is inconsistent with the present state of the earth's surface. Marvellous, too, as the results of investigation have been with regard to this fauna, it ought not to be forgotten, that it offers in many important respects an approximation to existing conditions, pointing rather to the increase of land in small spots, such as islands, than to any other change. The largest reptiles now existing frequently live in muddy spots, without any luxuriant vegetation in their vicinity, and far removed from the haunts of quadrupeds and birds. They are well known to bury themselves in mud, which often hardens about them, and they remain in this way in a state of torpor, until returning moisture—their muddy district being again flooded—recalls them to life and activity. The marine reptiles, and the huge land reptiles of the oolites, may thus have been very near neighbbours, and the low muddy banks, scarcely lifted above the level of high water and tenanted by the Plesiosaurus, may well have been succeeded or accompanied by low land of the same kind, on which the Megalosaurus could find food and shelter.

But there is considerable difference in the geographical position of those districts near which land existed during the carboniferous and the oolitic period. In the former we see coal or accumulations of vegetable matter dispersed in many isolated spots in Europe, as on the Rhine, near Düsseldorf, in Belgium, on the Moselle near Nancy, almost throughout France (although in quantities so small that the beds are rarely worked,) in the north of Spain, in Russia at the mouth of the Don, in Silesia, and in Bohemia. On the other hand, it is only in western England, western France, and central Germany that the reptiles and land animals of the oolitic period are found; and while in England they occur in all the rocks of that age, they have only been met with in France in the older, and in Germany in the newer rocks of the series.

It seems also not improbable, that, since in England and western France the oolitic strata were deposited on the eastern flanks of the older rocks, but in Germany on the southern, and in eastern Europe on their south-western side, the land may then have extended chiefly to the westward and south-westward, only existing in detached islands towards the north, and not reaching at all into high latitudes. There is not, however, much probability of there having been any great extent of land at this period in the district now occupied by Europe, for this area, during the earlier part of the period, was most likely marked by long-continued, slow depression, favourable to the formation of extensive and thick fossiliferous banks, and also admitting of the structure of coral reefs.

The period of the oolites, wherever those rocks are to be recognised, was one of local depression, but the close of the deposit was undoubtedly marked by elevation; and at that time land existed in and near the south-east of England, and may have formed part of a tolerably large tract. During the time when the remarkable series of Wealden deposits were being formed in fresh water, we are not aware of any corresponding marine beds in Europe; and this may have been owing to the existence of a great part of Europe as land during this period. In one small area in Scotland, and in North Germany (Hanover,) there are beds probably contemporaneous and of some interest; and these seem to render probable the vicinity of land where they were in process of formation; but whatever may have been the condition at that time, it soon became that of a marine district rapidly sinking; and the deep sea of the chalk period soon afterwards covered, with few exceptions, the whole land of Europe. The inhabitants of the sea hitherto known from the fossils of the chalk period are chiefly such as required deep water; and the effect being uniform over great tracts, the cause no doubt was the same, and acted in the same way.

The great and important want of continuity of the upper beds of the chalk with the beds deposited upon them in most parts of the world, cannot but be looked upon also as a most instructive fact, proving, it would seem, that, after the materials of these beds had been accumulated, there was a long interval during which they had time to consolidate, and become partially worn away. The deposits at that time probably formed the ocean-bed of a great eastern ocean ; while the main land of the period, if there existed any in these latitudes, occupied a tract extending towards the west and south, but scarcely reaching even the most westerly point of Europe.

At length, however, and *fifthly*, another change took place, the ocean-bed became elevated, land appeared near the south-western parts of England, extending, perhaps, to central France and Italy; and it may be that there was then commenced a great east and west movement of elevation, which, acting for a long time and by many successive efforts, has produced the important mountain chains of the eastern hemisphere; at first the Alps, the Pyrenees, and the Carpathians, and ultimately the Caucasus, and the Himalayan chain. It is, perhaps, something more than a mere vague hypothesis, to assume that these elevations acted first in the western and southern districts, producing the early deposits of the London, Hampshire, Brussels, and Paris Basins; and that they afterwards became more violent, elevating the Wealden district in England, while at the same time, or a little later, they formed the granitic axis of the loftier mountain districts.

These first deposits being formed, a tract of land was laid bare and became tenanted by large quadrupeds; and after many changes and elevations, a continent arose, not, indeed, the same in all respects as that which we call Europe, but exhibiting some of its chief physical features; and having a wider extension to the west, while the great valleys were still beneath the sea. A period, perhaps, succeeded this, when the land towards the north was more compact and higher; and then the great westerly districts which had long been at a much higher level than they now are, sank down to a depth of many hundred feet, so that the western lands quite disappeared, and only a number of small islands were presented in the spot now occupied by Great Britain and Ireland. Huge icebergs, and mighty waves, the result of subterranean and submarine disturbances, or conveyed from colder seas by marine currents, washed over many parts of our island, and of northern Europe, then under water; and thus the final surface of gravel was given. After this, one more great movement of elevation took place, mighty indeed, but slow, and acting by successive and repeated hitches, each of small amount, the effect produced being chiefly on the northern and western districts, but affecting the whole coast irregularly, not only with regard to England and Scotland, but even through Scandinavia up to the Arctic Circle.

Throughout the changes which have acted to make England what it is, we see no evidence in any part of its long history which can render probable any sudden modifications either of the earth's crust, or of the animals and vegetables by which the land and sea have been peopled. There is, in other words, no evidence to show that the whole of created beings have been at any one time swept off from the earth by the action of laws imposed upon matter from the beginning. The natural and necessary action of these laws does not seem to involve any great and general catastrophe.

Neither is there evidence of such interruption of the general system, as should at any one epoch have required a fresh creation of the whole series of organic beings. The ordinary method of succession of species, as of individuals, seems to have been during all time strictly adhered to, and this is a point of no slight interest and importance, since we can hardly otherwise comprehend any system, at least we cannot understand any general harmony to have existed, exhibiting the uniform action of a wise and perfect plan.

Nor can it be understood as a less noble or less striking proof of creative power, that in this great plan, according to which our globe was created, every thing should be foreseen and provided against, that every thing should succeed in its time and place, that each organized being should perform the task allotted to it, and retire when its work was done, having assisted to carry on, without interruption and without interference, the great and uniform system. The perfect relation of each animal and vegetable to the time and place allotted to it is no less marked and certain than that admirable adaptation of every part in the individual, which is known to be so necessary to its comfort and even its existence. The whole system is one, it is the result of one mind, of one will, of one power. It is governed by a few simple laws, which no power but that which instituted them can possibly interfere with, and which, so far as we can judge, never have been interfered with. It is permitted to man to become acquainted by careful observation with some of the methods thus adopted, and the laws imposed; and the power being given, it is surely incumbent on him to employ it, humbly indeed, and cautiously, but earnestly and with an honest desire to discover truth, whatever that truth may be, or however it may clash with his preconceived opinions.

INDEX.

[The names printed in Italics are those of fossils figured at the pages referred to.]

ACACIA-LIKE trees of Sheppey, 260.
Adams, Mr., his account of a Mammoth, 293.
America (South,) Tertiary Geology of, 330.
Ammonites (Liassic,) 142, 145.
——(Oolitic,) 187.
Ancient epoch, 30.
Animalcules, infusorial, 225.
Anoplotherium, 271.
Apiocrinite, 212.
Apteryx, 323.
Asia, Tertiary Geology of, 312.
Aspidorhynchus, 191.
Astræa, 183.
Aulopora, 43.
Auricula, 280.
Aurochs, Lithuanian, 302.
Australia, Tertiary Geology of, 320.
Azoic rocks, 35.

Bacillaria, 226.
Baculite, 236.
Bear of the Caverns, 297.
Belemnite, 149, 188.
Bellerophon, 102.
Beryx, 238.
Birds, fossil, of London Clay, 268.
Bourgueticrinus, 232.
Brachiopoda, account of, 51.
Brussels, older tertiary beds of, 260, 276.

Calamite, 93.
Calymene, 48.
Carboniferous period, 83, 110.
Catenipora, 44.
Caryocrinites, 47.
Caryocystites, 47.
Caverns, ossiferous, 297.
Cephalaspis, 74.
Cephalopoda, account of, 51.
—— (Silurian,) 54.
——(New Red Sandstone,) 124.
——(Liassic,) 142.
——(Oolitic,) 187.
—— (Cretaceous,) 234.
Ceratite, 124.
Cerithium, 261.
Cervus (Megaceros) hibernicus, 303.
Cetiosaurus, 192, 214.
Chain coral, 44.
Chalk, 221.
Chelonichthys, 79.
Chelydra, 281.
Chiracanthus, 80.
Chirotherium, foot-print of, 132.
Cidaris (Oolitic,) 185.
Cirrhopoda, account of, 50.
Cirrus, 103.
Clay slate, notice of, 33.
Coal, 86.
Coccosteus, 78.
Conus, 261, 280.
Coprolites, 172.
Coralline, Sertularian, 42.
Corals (Silurian,) 43, 44.
—— (Oolitic,) 183.
Corbula, 261.
Creseis, 53.
Cretaceous period, deposits of, 220.
——general condition of the sea during, 241.
Crinoidal animals (Silurian,) 46.
—— (New Red Sandstone,) 124.
——(Liassic,) 140.
—— (Oolite,) 183.
—— (Cretaceous,) 232.
Crioceratite, 235.
Cristellaria, 229.

Crustaceans, Oolitic, 185.
—— London Clay, 261.
Crystalline rocks, notice of, 31.
Ctenoid scale, 70.
Cycadeæ, 193.
Cycadeoidea, 194.
Cycas, recent, 194.
Cyclobatis, 266.
Cycloid scale, 70.
Cyprella, 99.
Cyrtoceras, 56.
Cystidea, 47.

Dapedius, 154.
Deer, fossil remains, of, 303.
Devonian period, 63.
Dicynodon, 130.
Didelphine animals of the Oolites, 193, 202.
Dinornis, 324.
Dinortherium, 281.
Dercetis, 239.
Dodo, 325.

Ear-bone of Whale, 305.
Edentata, notice of, 337.
Elephant or Mammoth, 288, 292.
—— Indian extinct species, 318.
Elk, Irish, 303.
Encrinites, 47, 124, 140, 183, 232.
Eocene or older Tertiary period, 275.
Epochs, tabular view of, 28.
—— ancient, 30.
—— middle, 121.
—— modern, 255.
Euomphalus, 103.

Fallow deer, horn of, 303.
Ferns, fossil, 91.
Fishes' scales, 70.
Fishes (Devonian,) 72.
—— (New Red Sandstone,) 124.
—— (Liassic,) 151.
—— (Oolitic,) 191.
—— (Cretaceous,) 236.
—— (Tertiary,) 262.
Fishes' tails, homocercal and heterocercal, 117.
Flint, formation of, 222.
—— fossils of, 223.
Flora (Carboniferous,) 91.
—— (Oolitic,) 193, 216.
—— (Tertiary,) 258.
Foot-prints, fossil, 127, 132.
Foraminifera, general account of, 229.
—— of the older Tertiaries, 261.
Gaillionella, 226.
Ganoid scale, 71, 72.
Ganoid fishes (London Clay,) 267.
Gasteropoda, account of, 50.
Gault, 221.
Glyptodon, 353.
Glyptolepis, 80.
Gneiss, notice of its formation, 33.
Gomphonema, 226.
Goniatites, 103.
Granite, account of, 31.
Graptolites, 42.
Gravel, fossils of, 291.
—— origin of, 306.
Greensand, 221.
Guttulina, 229.

Hamite, 236.
Hermit Crab, 232.
Heterocercal tail of fish, 117.
Hightea, 258.
Hippurite, 233.
Holoptychius, 81, 105.
Homalonotus, 49.
Homocercal tail of fish, 117.
Hyænas, number of, in caverns in England, 300.
Hylæosaurus, 208.

Ichthyodorulites, 107, 152.
Ichthyosaurus, 162, 173, 178.
Igneous rocks, notice of, 30.
Iguanodon, 205.
India, Geology of, 312.
Infusorial Animalcules, 225, 226.
Inoceramus, 234.
Insects (Lias and Oolitic,) 186.

Kirkdale Cavern, contents of, 298.

Labyrinthodon, 133.
Lebanon, fossil fishes of, 261.
Lepidodendron, 94.
Lepidosteus, scale of, 71.
Lepidotus, 155, 191.
Lias, account of, 139.
Lily Encrinite, 124.
London Clay, 259.
Lophiodon, 271.
Lower Greensand, 221.

Lucina, 261.

Machairodus, 302.
Macrauchenia, 336.
Macropoma, 237.
Magnesian Limestone, 110.
Mammoth buried in polar ice, 293.
Marsupial animals, account of, 204, 337.
Marsupite, 231.
Mastodon, 285.
Mechanical rocks, non-fossiliferous, 33.
Megaceros hibernicus, 303.
Megachirus, 185.
Megalichthys, 105, 106.
Megalodon, 70.
Megalonyx, 348.
Megalosaurus, 194, 216.
Megatherium, 339.
Metamorphic rocks, account of, 33.
Middle epoch, 121.
Millstone Grit, 85.
Mimosites, 259.
Miocene or middle tertiary period, 279.
Mitra, 280.
Modern epoch, 255.
Mollusca, divisions of, 50.
Monte Bolca, fossil fishes of, 262.
Mosasaurus, 239.
Murchisonia, 102.
Mylodon, 347.

Nautilus, general account, 54.
—— (Liassic,) 142.
Navicula, 226.
Neocomian, 221.
Neuropteris, 92.
New Red Sandstone, 121.
New Zealand, birds of, 324.
Nipad tes, 259.
Nodosaria, 22).
Nothosaurus, 157.
Nummulites, 261.

Odontopteris, 91.
Old Red Sandstone, 68.
Oolitic period, 181.
Opossums of the Oolites, 202.
Orthis, 53.
Orthoceratites, 56.
Osmeroides, 70, 233.
Ox, Irish, 303.

Pachycormus, 155.
Pagurus, 232.
Palæotherium, 271.
Pampas, account of, 331.
Paris Basin, characteristic fossils of, 269.
Pecopteris, 91.
Pecten, 280.
Pentacrinite, 141, 175.
Pentamerus, 53.
Perch, scale of, 70.
Peroids, Geological, tabular view of, 28.
Permian beds, 110.
Placodus, jaw and teeth, 126.
Placoid scale, 71, 72.
Plesiosaurus, 157, 178.
Plicatula (Cretaceous,) 233.
Pliocene or newer tertiary period, 289.
Pliosaurus, 192, 220.
Polypothecia, 225.
Polyps, account of, 43.
Polyptychodon, 239.
Productus, 101.
Pterichthys, 76.
Pterodactyl, 198, 216.
Pteropoda, account of, 50.
—— (Silurian,) 53.

Rays, fossil, (Lias,) 71, 155.
—— (Tertiary) from Lebanon, 266.
Reptiles (New Red Sandstone,) 126.
—— (Lias,) 156.
—— (Oolitic,) 191.
—— (Cretaceous,) 239.
—— (London Clay,) 267.
Rhine Valley, deposits and fossils of, 280.
Rhinoceros, extinct, found in polar gravel, 296.
Rynchosaurus, 129.
Rosalina, 229.

Salamander, gigantic, 280.
Salmon family represented in the London Clay, 264.
Sandstone, old red, 68.
—— new red, 121.
Sauroid fishes, 104, 155, 190, 237.
Scaphite, 235.
Scelidotherium, 348.
Sciænurus, 264.

Secondary series, general considerations on, 245.
Sedimentary rocks, non-fossiliferous, 32.
Serpent, fossil, of London Clay, 268.
Sertularian Coralline, 43.
Sewalik fossils, 315.
Sharks (Carboniferous,) 107.
—— (New Red Sandstone,) 126.
—— (Liassic,) 155.
—— (Oolitic,) 191.
—— (Cretaceous,) 238.
—— (London Clay,) 267.
Sheppey, fruits and other fossils found at, 259,
Siderolina, 229.
Sigillaria, 95.
Silurian period, 37.
Silurian seas, general condition, 57.
Siphuncle of Ammonite, 147.
Sivatherium, 317.
Sloth, gigantic extinct species allied to, 338.
Sphæronites, 48.
Sphærulite, 233.
Sphenopteris, 92.
Spiculæ of sponges, 224.
Spinacorhinus, 70, 155.
Spirifer, 101.
Sponges, fossil, 224.
Star-fish (Chalk,) 231.
Stigmaria, 95.
Stonesfield Slate, 192.
Succession, nature of, in Natural History, 65.

Tails of fishes, 117.
Tapir, account of, 270.
Teleosaurus, 214.
Terebratula (Carboniferous,) 102.
—— (Oolitic,) 186.
—— (Cretaceous,) 233.
Tertiary period, 255.
—— early condition, 275.
—— middle period, 279.
—— newer period, 289.
—— conclusion of, in England, 306.
Tetragonolepis, 154.
Thickness of the non-fossiliferous rocks, 34.
Tiger, fossil, of England, 301.
Tornatella (Cretaceous,) 234.
Tortoise, fresh-water, from Œningen, 281.
—— gigantic, of India, 316.
Toxodon, 333.
Tree ferns, 95.
Trigonia, (Cretaceous,) 233.
Trilobites (Silurian,) 48.
Trinucleus, 48.
Tunicata, account of, 50.
Turrilite, 236.
Turritella, 297.
Turtles (Cretaceous,) 240.
—— (Tertiary,) 267.

Ursus spelæus, 299.
Urus, 302.

Venus, 280.
Vulture, fossil, (London Clay,) 268.

Wealden deposit, 205, 219.
Whale's ear-bone, 305.
Wood, fossil, (Lias,) 140.

Xanthidium, 226.
Xiphodon, 273.

Zamia-like plants in New Red Sandstone, 135.

THE END.

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